DEVELOPMENT AND EVALUATION OF NEW STRATEGIES TO ENHANCE PUBLIC HEALTH REPORTING

by

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ABSTRACT

Public health reporting is an important source of information for public health investigation and surveillance, which are necessary for the prevention and control of disease. There are two important problems with the current public health reporting process in the United States: (a) the reporting specifications are unstructured and are communicated with reporting facilities using nonstandard public health department Web sites and (b) most reporting facilities transmit reports to public health entities using manual and paper-based processes. Our research focuses on the development and evaluation of new strategies to improve the public health reporting process by addressing these problems.

To improve the communication of public health reporting specifications by public health authorities, we: (a) examined the business process of a laboratory complying with the reporting requirements, (b) evaluated public health department Websites to understand the problems faced by reporting facilities while accessing the reporting specifications, (c) identified the content requirements of a knowledge management system for public health reporting specifications, (d) designed the representation of the public health reporting specifications, and (e) evaluated the content and design using a prototype web-based query system for public health reporting specifications.

To improve the transmission of case reports from healthcare facilities to public health entities, we: (a) described public health workflow associated with the management

of case reports, (b) identified the content of a case report to meet the needs of public health authorities, (c) modeled the case report using Health Level Seven (HL7) v2.5.1, and (d) evaluated the electronic case reports by comparing the timeliness, completeness of information content, and the completeness of the electronic reporting process with the paper-based reporting processes.

We demonstrated a model for public health reporting specifications using a prototype web-based query system. The evaluation conducted with users from laboratories, healthcare facilities, and public health entities showed that the proposed model met most of the users' needs and requirements. We also identified variation in the reporting specifications, some of which could be standardized to improve reporting compliance.

We implemented HL7 v2.5.1 case reports from Intermountain Healthcare hospitals to the Utah Department of Health. The electronic reports transmitted from the Intermountain hospitals were more timely (median delay: 2 days) than the paper reports sent from other clinical facilities (median delay: 3.5 days) but less timely than the paper reports from Intermountain laboratories (median: 1 day). However, the evaluation of the completeness of data elements needed for public health triage prior to investigation showed that electronic case reports from Intermountain hospitals included more complete information than paper reports from Intermountain laboratories. Even though the paper reports from Intermountain laboratories were more timely, the incomplete reports may delay investigation. There are informatics opportunities and public health needs to improve both electronic laboratory reporting and electronic case reporting.

To My Family

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CHAPTER 1

INTRODUCTION

Public health investigation and surveillance is critical for the prevention and control of communicable and non-communicable diseases. For this purpose, every state in the United States publishes a list of `reportable diseases' that functions as a communication tool between public health entities and reporting facilities regarding the conditions reportable in that state. When a reportable condition is identified, clinicians and laboratories are required to report the event to public health authorities [1, 2, 3, 4, 5]. The reports help public health authorities to make informed decisions and implement appropriate control measures to prevent new occurrence of infectious diseases or injuries. Hence, the ability of public health authorities to communicate reporting specifications to potential reporters impacts the quality and timeliness of the reports and the quality and timeliness of the implementation of control measures. Incomplete or delayed reports can result in new occurrences of disease that could have been prevented. Figure 1.1 describes the two-way communication required between public health authorities and reporting facilities to enable public health investigation and surveillance.

There are several problems and challenges with the current reporting process in the United States. First, the reporting specifications vary across jurisdictions, change over time, and are distributed across various public health websites in numerous formats [6]. Second, there is no single resource that helps reporting facilities identify the reporting

specifications for all jurisdictions, making it challenging for reporting facilities to keep track of the various reporting specifications. Third, reporting facilities primarily transmit case reports to public health authorities using paper-based and manual processes. These manual processes have been found to suffer from delayed reporting, missing paper reports, incomplete information in a report, and errors in manual data entry [7, 8].

There have been national efforts to aggregate the reporting specifications across various jurisdictions. The Council of State and Territorial Epidemiologists (CSTE) has developed a web-based data query system that summarizes the conditions reported in the United States [9]. Since 2008, the data in the system is updated by epidemiologists from every state annually. However, the query system has the following features that make it unsuitable as a public health knowledge repository for reporting facilities such as laboratories and clinical facilities: (a) it does not represent all jurisdictions (for example, it does not include Los Angeles County Health Department which reports directly to the Centers for Disease Control and Prevention (CDC) and has its own reportable condition list independent of the California Department of Public Health), (b) it focuses on only those conditions that are nationally notifiable and hence does not include all conditions reportable in every state, (c) the reporting specifications for various states are not represented using standards and are not provided in a format that is machine readable, making it difficult for reporting facilities to use the data for automated detection of reportable conditions, and (d) it does not include information needed by reporting facilities such as the reporting time frame and the reporting methods.

Electronic systems that transmit laboratory data for reportable diseases to health departments have been implemented in a few states [10, 11, 12]. Research has demon-

strated that electronic laboratory reporting (ELR) has the potential to have a positive impact on disease reporting [13]. However, it has also been found that ELR created new problems in data quality, shifted work demands, required additional skills for data monitoring [14], and should not replace the clinician's responsibility to submit case reports to public health [15]. Moreover, there are major disadvantages with ELR-based systems: only diseases diagnosed using laboratory tests are identified; and ELR messages often do not include patient demographics, location, and clinical data that are important for public health investigation, surveillance, and case management. These drawbacks indicate the need for electronic case reporting in addition to ELR.

Recent policy changes such as the Health Information Technology for Economic and Clinical Health (HITECH) Act and the proposed inclusion of public health reporting as a criterion for complying with Meaningful Use requirements have increased opportunities for electronic case reporting [16]. While an electronic case report may contain laboratory results similar to an ELR message, a case report also includes information about patient demographics, clinical findings, and other relevant data that can be extracted from the Electronic Health Record (EHR). Previous systems that automated the transmission of case reports were limited to a few selected diseases [17].

The problems with the current reporting process purport an urgent need to use informatics tools and techniques to enable: (a) public health authorities to improve their communication with reporting facilities by actively publishing their reporting specifications and (b) healthcare facilities to improve their communication of existing reportable events with public health authorities by electronically transmitting standardized case reports.

To address the problems of the current public health reporting process, we conducted research in two areas. First, we focused on the requirement for a resource to share reporting specifications. The objective of this research was to (a) understand the problems associated with current methods of communication of the reporting specifications from the perspective of reporting facilities, (b) identify the content required to model the reporting specifications, (c) design the representation of public health reporting knowledge to meet user-defined needs and identify additional requirements, and (d) evaluate the usability of a web-based public health reporting system. The problem analysis is described in Chapter 2. The processes of identifying the content to model the reporting specifications and designing the content representation are described in Chapter 3. The usability evaluation of the web-based public health reporting system is found in Chapter 4.

Second, we focused on the electronic transmission of case reports from healthcare facilities to public health entities. The objectives of this research were to: (a) identify the requirements of electronic case reports to support public health workflow, (b) model an electronic case report using HL7 v2.5 to transmit case reports electronically from healthcare facilities to public health entities, and (c) evaluate the electronic reporting process with the existing paper-based reporting process. A description of the requirements we identified and the model we proposed to transmit an electronic case report is found in Chapter 5. The evaluation of the electronic case reporting process is described in Chapter 6.

The research described in this dissertation has required much involvement from personnel at public health entities at the national, state, and local level, as well as hospi-

tals and laboratories. We summarize the challenges we faced, the lessons learned while working with these different entities, and the current status of the two areas of research in Chapter 7. Finally, the conclusions of this research will be shared in Chapter 8.

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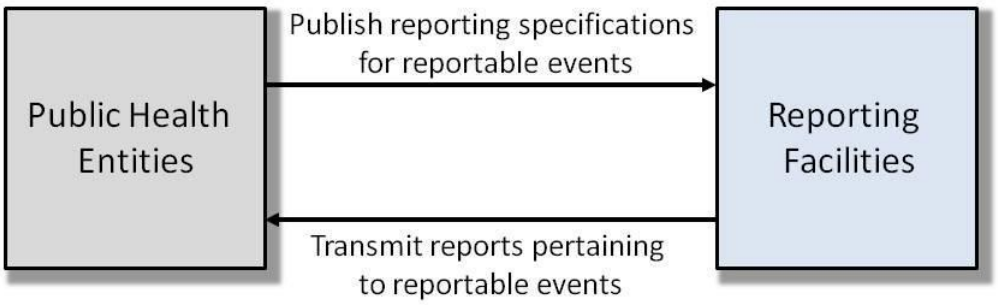

Figure 1.1: Two-way communication required for public health reporting

CHAPTER 2

PUBLIC HEALTH REPORTING: PROBLEMS FACED BY REPORTING FACILITIES

Introduction

Public health reporting is a complex process that includes multiple steps. It is generally thought that the process begins when reporting facilities transmit reports of reportable diseases to public health entities. However, as seen in Figure 2.1, the process is initiated by public health entities when they define reporting specifications and communicate these specifications to reporting facilities. Reporting facilities are responsible for accessing the reporting specifications, identifying the existence of reportable events, and reporting the events to public health entities. Public health departments receive the reports, conduct case investigations, implement control measures when required, and conduct public health surveillance.

Reporting specifications are currently shared as `reportable disease lists and rules' on public health department web sites and as paper-based posters [1, 2]. This method of communication includes several problems. A few examples of the problems are: (a) The reporting specifications are not represented in a computable format and hence cannot be downloaded by reporting facilities wanting to implement automated detection of reportable events and (b) the reporting specifications are scattered across different health de-

partment web sites making it difficult for reporting facilities to find and comply with the reporting requirements for multiple jurisdictions.

The Rocky Mountain Center of Excellence in Public Health Informatics was funded by the CDC to develop a prototype knowledge management system that would allow public health authorities to author, manage, and communicate reporting specifications using existing standards in human-readable and computable formats. To understand the requirements of such a system, we explored the problems associated with current methods of communication for reporting specifications focusing on the perspective of reporting facilities.

The requirements of a public health laboratory information management system and the associated business processes relating to laboratory test processing, test scheduling, specimen tracking, media manufacturing, and inventory control have been described in the literature [3]. However, we found no description of the business process relating to laboratory reporting to public health authorities in the literature. This gap must be addressed to develop systems to support the business process relating to public health reporting from a laboratory.

Objectives

The research described in this chapter had two main objectives:

1. Describe the business process for a laboratory to comply with reporting requirements.
2. Identify problems faced by reporting facilities when accessing reporting specifications communicated on public health department web sites.

Methods

To meet the objectives of the research, we followed two main methods:

1. Business Process Analysis:

To understand the business process of public health reporting from a laboratory, we conducted an ethnographic study in Fall 2009. The study involved direct observations of the work processes of a reporting compliance officer at a national reference laboratory that reports to multiple public health departments in the United States. The observation study was conducted by one researcher (DR). During the observation study, we identified the different tasks conducted by the reporting compliance officer while engaged in public health reporting. After the observation study, we documented the business process of public health reporting at the laboratory and conducted follow-up interviews with the reporting compliance officer to confirm that the documented business process was accurate. To improve generalizability, we also interviewed personnel at a central laboratory for a multihospital healthcare enterprise and validated our findings.

2. Analysis of Current Public Health Department Websites Using Heuristic Evaluation:

In Spring 2010, we reviewed three public health department web sites to identify the problems faced by reporting facilities when accessing reporting specifications. We used the Nielsen-Shneiderman heuristic evaluation method [4] and the 14 heuristics proposed by Zhang et al. [5]. A list of the 14 heuristics can be found in Table 2.1. Two evaluators (a biomedical informatics graduate student (DR) and a medical student) evaluated the web sites of the Colorado Department of Public Health and Environment (CDPHE) [6], the Utah Department of Health (UDOH) [7], and the Washington State Department of Health (WADOH) [8]. Since the purpose was to identify the problems faced by report-

ing facilities while accessing the reporting specifications from public health department web sites, we re-created the workflow of a reporter responsible for public health reporting. We compiled 10 scenarios and specified a list of associated tasks that would typically be conducted while identifying the reporting specifications. The scenarios were based on a user from a clinical or a laboratory setting tasked with (a) identifying if a specific disease (e.g., Hepatitis A) is reportable, (b) identifying if a specific injury (e.g., pesticide illness) is reportable, (c) finding the reportable disease list, (d) finding the reportable injury list, and (e) finding the reportable disease and reportable injury rule. The scenarios were based on a user from a clinical or a laboratory setting tasked with (a) identifying if a specific disease (e.g., Hepatitis A) is reportable, (b) identifying if a specific injury (e.g., pesticide illness) is reportable, (c) finding the reportable disease list, (d) finding the reportable injury list, and (e) finding the reportable disease and reportable injury rule. The evaluators performed the specified tasks for all the scenarios for each of the three public health department web sites. During the performance of each task, the evaluators documented the number of clicks and used a stop-watch to identify the time taken to obtain the information required for the specific tasks. After completing the tasks associated with each scenario, the evaluators reviewed the 14 heuristics and determined if a specific heuristic was violated during a task. The severity of the violations were rated using a scale of 0 to 4 (0: not a usability problem, 1: cosmetic problem, need not be fixed unless extra time is available, 2: minor usability problem, fixing this should be given low priority, 3: major usability problem, fixing this should be given high priority, 4: usability catastrophe, imperative to fix).

A detailed description of two of the scenarios and associated tasks are as follows:

Scenario 1: You are working at a clinician's office and there is a patient who has been diagnosed with Hepatitis A. You have been given the task to report this case to public health if necessary.

Tasks 1:

i. Go to http://www.cdphe.state.co.us/
ii. Find out if Hepatitis A is reportable in Colorado
iii. Identify the timeframe within which you need to report Hepatitis A
iv. Identify the method by which you have to transmit the report (e.g., fax, email, phone, etc.)

Answer the following questions:

i. Are there steps that you have to memorize to navigate the required information?
ii. Were you able to find out if Hepatitis A is reportable in Colorado?
iii. Is there information regarding the timeframe within which Hepatitis A is to be reported?
iv. Is there information on the method of reporting?
v. Do you think any of the 14 heuristics were violated while you conducted the tasks? Specify the violated heuristics.

Scenario 2: You are working at a laboratory. To organize the reporting process from the laboratory to the public health department, you want to find the list of reportable diseases that would help you identify the complete set of diseases that are reportable in Colorado.

Tasks 1:

i. Go to http://www.cdphe.state.co.us/

ii. Start the stop-watch

iii. Find the reportable disease list for laboratories

iv. Stop the stop-watch

Answer the following questions:

i. Were you able to find the reportable disease list for laboratories?

ii. If `No', how much time did you spend searching for the list before giving up?

iii. If `Yes', how long did it take you to find the list from the Web site home page?

iv. How many clicks did it take from the Web site home page to find the list?

v. Is there a link to the reportable disease list from the Web site home page?

vi. Are there steps that you have to memorize to navigate to the list?

vii. Is there a separate reportable disease list for healthcare providers and laboratories?

viii. Based on the list, can you identify how and where to submit specimens?

ix. Do you think any of the 14 heuristics were violated while you conducted the tasks? Specify the violated heuristics.

Results

The results of the ethnographic study and the analysis of the public health department websites are described below:

1. Business Process Analysis:

We found that the laboratory work process can be separated into two domains: (a) testing and data domain and (b) compliance and reporting domain. Figure 2.2 describes the flow of information between the laboratory setting and the clinical and public health settings. We focused on the compliance and reporting domain and found that it included the following tasks:

i. Seek public health reporting logic and specifications:

We found that this was a manual process and was conducted by the reporting compliance officer by accessing the public health reporting specifications displayed on individual public health department web sites. This task was performed when the laboratory was setting up an automated detection system to identify reportable events.

ii. Identify new public health reporting logic and specifications:

This was also a manual-driven task conducted by the reporting compliance officer to identify new or updated reporting specifications. The process included a review of the reporting specifications on the public health department web sites. It is supposed to be conducted annually, but most of the time, the process is initiated when public health departments contact the reporting compliance officer to inform them of new specifications or updates to current specifications.

iii. Integrate public health specifications:

This was also a manual-driven process which involved the integration of new and updated public health reporting specifications into the automated detection system used in the laboratory.

iv. Apply evidence detection logic:

This was an automated process to detect laboratory results associated with clinical events and the results were stored in the data warehouse.

v. Apply reporting specifications logic:

The public health reporting logic was used to automatically detect public health reporting events. For example, the age criterion was applied to detect a reportable blood lead level.

vi. Create a `public health report':

Once a public health reportable event was identified, a `public health report' was automatically generated and sent to the reporting compliance officer.

vii. Review and finalize `public health report':

The report was manually reviewed by the reporting compliance officer to ensure that the reporting requirements for the specific jurisdictions are met. The reporting compliance officer maintained a data-store of information on patients that she accessed to obtain any information that was missing in the automatically generated `public health report'. The time taken by the reporting compliance officer to review and finalize the `public health reports' was found to vary from 40 minutes to 2 hours per day depending on the volume of reports. For example, some of the problems faced by the reporting compliance officer while finalizing the `public health report' are as follows:

a. The New York City Department of Health and Mental Hygiene and the Ohio Department of Health required that all reports for HIV and elevated blood lead level respectively included patient addresses. Since a blank patient address could not be sent in the report, the reporting compliance officer had to manually enter `No patient address' in the reports if the address was not available from the laboratory order.
b. Health departments at South Carolina, Los Angeles County, and Virginia require that the PCR results be specified in copies/mL. However, the result in this specific unit was present in a comment field in the patient's report in the data warehouse and had to be manually extracted by the reporting compliance officer and inserted into the `public health report'.

c. The reporting compliance officer could enter patient information for elevated blood lead level reports until the report was verified by personnel conducting the laboratory test. The verification process usually took about two days, thus delaying the reporting of elevated blood lead levels by two days.

viii. Transmit the 'public health report':

The 'public health report' was transmitted to the appropriate health department using the required method of reporting (e.g., Fax, Postal mail, Secure file transfer, etc.).

2. Analysis of Current Public Health Department Websites using Heuristic Evaluation:

During the heuristic evaluation of the CDPHE, the UDOH, and the WADOH web sites, we found that six of the 14 heuristics were violated. A few of the problems found during the execution of the specified tasks are described in Table 2.2. All three web sites violated the Match heuristic while attempting to access the list of reportable injuries. Both the CDPHE and the WADOH web sites did not have an explicit list of reportable injuries and the UDOH web site displayed the list of reportable injuries as part of the injury rule. Both the CDPHE and the WADOH web sites violated the Minimize memory load heuristic because the navigation required to get to the reportable disease lists is not straightforward. The CDPHE web site does not have a direct link to the reportable diseases and the WADOH web site has a link to the reportable diseases at the bottom-right of the homepage. Thus, requiring the users to remember these unique characteristics for future reference. The severity of the violations ranged from 1 (cosmetic) to 3 (major). We present screen-shots of the CDPHE and the UDOH web sites as examples of the heuristic violations in Figures 2.3 and 2.4. The time taken to obtain the information varied from 10 seconds to 6.5 minutes (at which time the evaluators stopped trying to find the list of re-

portable injuries for Washington). The minimum number of clicks to complete the specified tasks was four for CDPHE, two for UDOH, and three for WADOH. We also found that the CDPHE and WADOH Web sites have separate reporting specifications for laboratories and healthcare providers. But, the UDOH web site does not have separate reporting specifications for laboratories and healthcare providers. We presented these results as a poster at the Annual Meeting of the American Medical Informatics Association, 2010 [9].

Discussion

Public health departments publish the reporting specifications for events reportable in their jurisdiction on individual web sites. In this chapter, we have focused on understanding the problems faced by reporting facilities while complying with the reporting requirements. Using ethnographic methods, we were able to document the business process of public health reporting at a national reference laboratory.

During the ethnographic study conducted at the national reference laboratory that uses automated detection logic to identify reportable events, we found that the reporting compliance officer spends between 40 minutes to two hours every day to review and finalize the public health report.

This does not include the time taken by the reporting compliance officer to identify new or updated reporting specifications. It also does not include the time and effort taken to integrate the specifications into the automated detection system. Therefore, even though a laboratory may have automated detection logic to identify reportable events, the business process of laboratory reporting continues to involve several manual processes.

We believe that the reporting effort for laboratories without automated detection logic would be more extensive. Thus, a considerable amount of effort is required by the laboratories to comply with public health requirements for multiple jurisdictions. We think this is because currently, it is the onus of the reporting facilities to interpret the reporting specifications posted on individual health department Web sites, develop an automated detection system for reportable events, and update the system when reporting specifications are updated.

The methods used to analyze the business process of laboratory reporting have limitations. In particular, the observation study was performed at only one national reference laboratory. To begin to address this limitation, we validated our findings by interviewing personnel at a central laboratory for a multihospital healthcare enterprise. However, since both laboratories have an automated detection system, we recommend that our findings be verified with a laboratory that does not have automated detection systems.

The results of the heuristic evaluation of the three public health department web sites showed that none of the web sites fully conformed to accepted heuristics. We also found that the display of information was not targeted to specific audiences. For example, the UDOH web site does not publish separate reporting specifications for laboratories and clinical facilities. It is possible that the participation in mandatory reporting may improve if the information and design were audience-specific.

To conclude, analyzing the problems associated with public health reporting from the perspective of reporting facilities provided insight into the challenges faced by reporters complying with public health reporting requirements. Our findings suggest that the current methods used by public health authorities to publish reporting specifications do

not meet the needs of the reporting facilities. We recommend involving representatives from different types of reporting facilities in the design and evaluation of tools developed in the future to public health reporting specifications.

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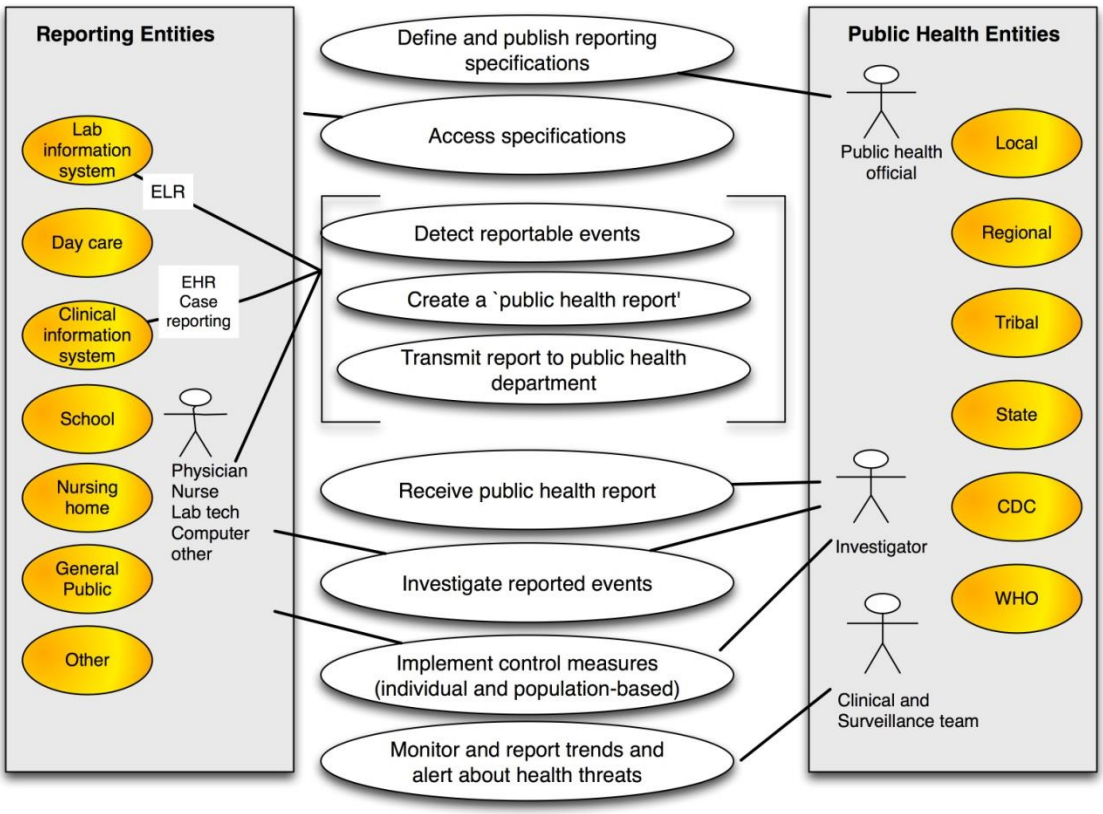

Figure 2.1: Public health reporting use case

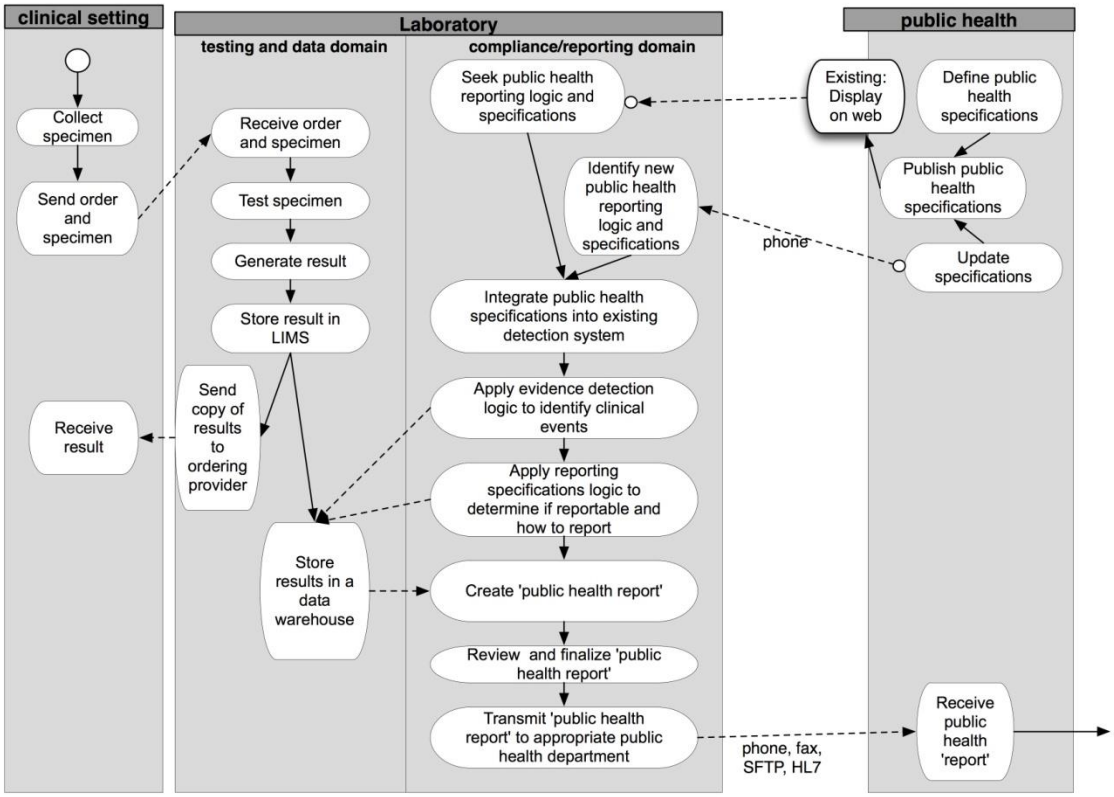

Figure 2.2: Business process of public health reporting identified at a laboratory

Figure 2.3: Navigation required to access the reporting specifications for Colorado: violating the Efficiency, the Memory, and the Match heuristics (2010).

Figure 2.4: Accessing the reporting specifications for injuries for Utah: the different color schemes violate the Consistency heuristic (2010).

Table 2.1: Heuristics used to evaluate public health department webs sites (proposed by Zhang et al.)

Heuristic	Description
Consistency and standards [Consistency]	The users should not have to wonder whether different words, situations, or actions mean the same thing.
Visibility of system state [Visibility]	The user should not have to wonder where they are in the system, what they can do next, or what has happened after an action.
Match between system and real world [Match]	The image of the system perceived by the users should match the model the users have about the system.
Minimalist	This involves judging whether any extraneous information is a distraction and a slow-down.
Minimize memory load [Memory]	Users should not have to memorize a lot of information to carry out tasks. Memory load reduces user's capacity to carry out the main task.
Informative feedback [Feedback]	The system should provide feedback about the user's actions.
Flexibility and efficiency [Flexibility]	The users should be allowed to use shortcuts or tailor frequent actions for their own needs.
Good error messages [Message]	The system should alert the users to potential errors. The messages should be clear and precise.
Prevent errors [Error]	The system has mechanisms in place to prevent errors from occurring.
Clear closure [Closure]	The completion of a task is clearly indicated.
Reversible actions [Reversible]	The system allows the users to easily backtrack.
Use user's language [Language]	The language should be presented in a form understandable by the intended user.
Users in control [Control]	The user should be able to leave an unwanted state easily.
Help and documentation [Document]	The user should be provided with easily accessible help and documentation.

Table 2.2: Summary of usability violations observed in three public health department web sites

Tasks	Usability Problem Description	Heuristics Violated	Severity
Colorado Department of Public Health and Environment			
Identifying if Hepatitis A is reportable	There is no link to the reportable diseases from the home page. We had to navigate through a 'Health A to Z' index.	Efficiency Memory Match	3 3 3
Finding the list of reportable injuries	There is no specific list of reportable injuries- we found a pdf file under regulations that states a few injuries that are reportable but it does not specify the reporting specifications.	Match	3
Utah Department of Health			
Finding the list of reportable injuries	The user needs to navigate through multiple screens with different color schemes to find the list of reportable injuries.	Consistency	1
	There is no separate list of reportable list –it is part of the injury rule	Match	1
	The user is required to click on 'Report a Disease' to obtain information in reportable injuries- the 'Violence and Injury Prevention' link does not lead to a reportable injury list.	Match Language Visibility	2 2 2
Identifying the details regarding the submission of specimen	The reportable disease rule requires submissions of isolates of certain specimens but this is not stated in the reportable disease list.	Consistency	2
Washington State Department of Health			
Finding the list of reportable diseases	The link to the reportable disease list is displayed at the bottom of the home page- we had to scroll down to find the link.	Memory	3
Finding the list of reportable injuries	There is no specific list of injuries	Match	2
Severity scale: 1: cosmetic, 2: minor, 3: major			

CHAPTER 3

PUBLIC HEALTH REPORTING SPECIFICATIONS: CONTENT ANALYSIS AND REPRESENTATION

Introduction

Public health departments publish the reporting specifications for conditions reportable in their jurisdiction on their individual websites. These reporting specifications vary across jurisdictions and change over time [1]. For example, during a six month period in 2003, 16 of 52 jurisdictions in the United States had updated the list of conditions reportable in their jurisdiction [2]. This may make it difficult for reporting facilities such as laboratories, hospitals, and healthcare providers to comply with reporting requirements in multiple jurisdictions. As the use of information technology becomes more prevalent in clinical and public health settings, there are increasing opportunities for public health authorities to author, update, and maintain the reporting specifications using a public health knowledge management system.

There have been various efforts to aggregate the reporting specifications across jurisdictions and standardize the reporting requirements for specific events but each effort has limitations. Since 2008, the Council of State and Territorial Epidemiologists (CSTE) has been conducting an annual assessment of all conditions reportable in the states in the United States. The results are presented using a web-based data query system [3] called the State Reportable Conditions Assessment (SRCA). However, the SRCA tool cannot be

used by laboratories and clinical facilities as a public health knowledge repository for the following reasons: (a) it does not include all jurisdictions, and (b) it does not capture information needed by reporting facilities to report events to public health authorities such as the reporting time frame and the reporting methods (e.g., phone, fax, etc.) [4]. A 'knowledgebase' of reportable conditions was described in Doyle et al [2]. However, it does not include concepts pertaining to the reporting time frame and the reporting methods. It also does not include a web-based system that can be used by reporting facilities to query the knowledgebase. Since 2009, a workgroup consisting of representatives from the CSTE and epidemiologists across the Unites States has worked on standardizing the reporting specifications for nationally notifiable conditions. Documents referred to as `Position Statements' are available from the CSTE website [5]. The Position Statements define national policy, but they do not address all the specifications required to implement public health reporting such as the reporting time frame and the available methods for reporting.

Studies have shown that involving users during the development of an information system is important to enhance both system usage and user satisfaction [6]. While usability techniques involving actual users have been extensively adopted for application design and development in non-medical fields, these techniques are less common in the healthcare and public health fields. The International Organization for Standardization defines usability as `the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use [7]. Over the last few years, there have been several efforts in the United States to improve the usability of electronic health records. National organizations such

as the National Institute of Standards and Technology (NIST) and Health Information Management Systems Society (HIMSS) are creating guidelines, measures, and usability evaluation standards [8, 9] to improve the adoption of usability testing in healthcare. However, we found no evidence in the literature regarding the application of usability techniques during the development of public health systems.

To address the gap in the reporting specifications and the literature, and benefit from usability techniques, we focused on modeling public health reporting specifications based on input from users representing public health departments, laboratories, and clinical settings.

Objectives

The research described in this chapter had two main objectives:

1. Identify the content required to define public health reporting specifications for laboratories and clinical facilities.
2. Represent the content based on user-specified needs.

Methods

To meet the objectives of the research outlined in this chapter, we followed several methods.

1. Content Analysis for Public Health Reporting Specifications:

In Spring 2010, we identified the content required to model public health reporting specifications using the following methods:

i. Review of reporting specifications:

In Spring 2010, we conducted a review of the reporting specifications published in three public health department web sites: Colorado Department of Public Health and Environment (CDPHE) [10], Utah Department of Health (UDOH) [11], and Washington State Department of Health (WADOH) [12]. We focused on the lists of reportable diseases that were published by the public health departments for use by laboratories and clinical facilities. These lists were not the reporting rule or the law, but rather a condensed representation of the reporting specifications meant for communication with reporting facilities. The review was based on six reportable disease lists: one reportable disease list from the UDOH, two reportable disease lists from the CDPHE for laboratories and clinical facilities, and three reportable disease lists from the WADOH for laboratories, hospitals, and providers. Since Colorado and Washington have different reportable disease lists for laboratories and clinical facilities, we grouped the clinical and laboratory criteria that represented the same reportable event. For example, Anthrax and *Bacillus Anthracis* were counted as one event.

As part of the review process, we documented the reporting time frame for the events reportable from clinical facilities and laboratories. We also identified the variation in the events that were reportable explicitly (specifically stated in the reportable disease list) in the three states.

ii. Review of blood lead level reporting criteria as published on public health department web sites:

We documented the reporting logic of one reportable injury, elevated blood lead level. We chose lead poisoning because it is one of the most common diseases of envi-

ronmental origin [13]. It is reportable in most states in the United States but the reporting criteria vary by state [3].

iii. Defining the content of public health reporting specifications:

We identified the different concepts needed to describe the reporting specifications for public health reportable conditions and we graphically represented the concepts using CMap [14]. During this process, we reviewed the Position Statements [5] to identify the content required to specify the laboratory findings needed to identify reportable events.

iv. Structured interviews with public health personnel in Utah to assess content:

We conducted structured interviews at the UDOH with two epidemiologists who were responsible for the surveillance of elevated blood lead level and streptococcal disease. The objectives of the interviews were to identify additional content requirements and obtain the public health perspective regarding the concepts that are relevant for public health reporting. The script used in the structured interviews can be found in Appendix A.

2. Content Representation of Public Health Reporting Specifications based on Principles of Usability Testing:

In Fall 2010, we focused on representing the public health reporting specifications based on the needs of users from public health departments and reporting facilities. We used the following methods:

i. Design of low-fidelity mock-ups:

We designed low-fidelity mock-ups to represent the public health reporting specifications for Colorado, Utah, and Washington. Low-fidelity mock-ups are low-cost de-

sign representations that are not interactive and are typically created prior to the development of interactive systems. The mock-ups were designed using Microsoft Powerpoint to meet the following objectives: (i) to obtain user-input from representatives from public health and reporting facilities and (ii) to inform the development of an interactive web application (described in Chapter 4).

ii. Usability testing with representatives from public health departments and reporting facilities:

Using the low-fidelity mock-ups that we designed, we conducted usability tests with users from public health departments, laboratories, and clinical facilities. The goal of the test sessions was to obtain user-specified input on the content representation defined in the mock-up views. The test sessions with 11 users were conducted using the think-aloud usability method [15, 16, 17, 18, 19]. The users included (a) five epidemiologists from state and local public health departments at the UDOH, the WADOH, the Salt Lake County Health Department, the Denver Public Health Department, and the Spokane Regional Health District, (b) two reporting compliance officers from a national reference laboratory and a central laboratory for a multi-hospital healthcare enterprise, (c) two infection preventionists from two major healthcare enterprises in Utah, and (d) two physicians from two major healthcare enterprises in Utah.

The usability sessions were conducted between November 3 and December 8, 2010 with one or two users in each session. At the beginning of each usability session, we oriented the users about the purpose of the usability tests. The script used during the sessions can be found in Appendix B. During the study, we recorded the conversations that took place and we reviewed the tape after each usability session to document the user's

needs that were identified during each session. The usability test sessions with remote users were conducted using GoTo Meeting [20]. This allowed us to simulate an in-person usability test session with users not located in Utah. After each usability test session, we updated the mock-ups to reflect the new requirements identified in that session.

IRB exemption for the usability sessions was obtained from the University of Utah.

Results

The results of the content analysis and the content representation methods are summarized below:

1. Content Analysis for Public Health Reporting Specifications:

i. Review of reporting specifications:

We found that there was variation in the reporting time frames for the three states. We also found that the reporting time frame within a state varied by type of reporting facility. For example, Washington specifies different reporting time frames for laboratories and clinical facilities even for the same disease. Table 3.1 illustrates the variation identified in 2010.

During the review process, we also found variation in the criteria used to identify the responsible jurisdictions among the three states. Table 3.2 illustrates the variation in Colorado, Utah, and Washington. The reporting specifications published on the CDPHE and the WADOH websites explicitly specified how the responsible jurisdiction is determined in their states. The specifications published on the UDOH website does not explicitly state the criteria used to determine the responsible health departments, however the specifications include a requirement for the patient's address in the report.

We found 82 events that were reportable in either Colorado, Utah, or Washington, but only 46 (56%) of the events were reportable in all three states. As seen in Figure 3.1, there were 63, 70, and 57 events that were reportable in Colorado, Utah, and Washington. Of the 82 reportable events identified on the three web sites, only 46 (56%) were reportable in all three states. Ten events (e.g., Coccidioidomycosis, Colorado tick fever) were reportable only in Utah, seven events (e.g., Typhus, Herpes) were reportable only in Washington, and three events (e.g., Kawasaki syndrome) were reportable only in Colorado. 58 events were commonly reportable in Utah and Colorado, 48 events were commonly reportable in Utah and Washington, and 48 events were commonly reportable in Colorado and Washington.

The complete list of events reportable in the three jurisdictions and the corresponding reporting time frames can be found in Appendix C. During the compilation of the list, we found other examples of variation in the reporting specifications for Colorado, Utah, and Washington. We summarize some of our findings in Table 3.3.

ii. Review of blood lead level reporting criteria as published on public health department web sites:

We found that the reporting criteria for elevated blood lead level varied across Utah, Colorado, and Washington by: blood lead level, patient's age, and reporting time frame. As seen in Table 3.4, the reporting criteria in the three states involved two blood lead level cut-offs: 10 μg/dL and 25 μg/dL, two age cut-offs for the patient: 15 years and 18 years, and four reporting time-frames: within two working days, within seven working days, within 30 days (and one month), and within 60 days. The logic for reporting ranged from simple logic in Utah to more complex logic in Colorado and Washington.

iii. Defining the content of public health reporting specifications:

The findings described previously helped determine that public health reporting specifications are represented by two primary concepts: Reportable Event and Reporting Action. The `Reportable event' was defined to include the following: laboratory findings (laboratory test name, laboratory test result, specimen source, laboratory test status), clinical findings (clinical condition, diagnosis certainty, pregnancy status, vital status, cause of death), type of reporter (laboratory, healthcare provider, hospital), jurisdiction (address of reporting facility or patient), age criteria, and encounter data (hospitalization status, hospitalization duration). The `Reporting Action' was defined to include the following: reporting time frame, receiving entity, reporting methods, requirement of specimen submission, and link to reporting form. Figures 3.2 and 3.3 describe the concepts associated with the reportable event and reporting action respectively.

iv. Structured interviews with public health personnel in Utah to assess content:

The following findings were elicited from our interviews with the public health epidemiologists at the UDOH:

a. Public health epidemiologists expect reporting facilities to review the communicable disease list and not the communicable disease rule to identify the reporting requirements for diseases.
b. Public health epidemiologists expect reporting facilities to review the reportable injury rule (there is no reportable injury list) to identify the reporting requirements for injuries.

c. The core data elements required to identify reportable events are: laboratory test name, laboratory test result, specimen source, laboratory test status (for laboratories), clinical condition, and diagnosis certainty (for clinical facilities).
d. Other constrains such as pregnancy status, vital status, and age criteria are relevant for a few diseases but not all.
e. It is important that reporting facilities know the following data elements: Reporting time frame, URL for public health department website, URL for disease list, URL for injury rule, URL for the reportable condition form, date of last update of specifications, preferred reporting method, other reporting methods, contact information for the health department receiving the report (name, address, phone number), contact information for the entity receiving the specimen (typically the public health state laboratory), and the specimen submission details.
f. The health department wants reporting facilities to report cases for patients residing outside Utah when the laboratory results are generated in a laboratory in Utah and the health encounter occurred in Utah. The UDOH will route the report to the appropriate jurisdiction.
g. There is a discrepancy between the reporting requirements stated in the reporting rule and what is needed by public health officials involved with case management and surveillance of lead poisoning. For example, the reporting rule specifies that `elevated' blood lead levels must be reported within 60 days. However, in practice, public health officials at the UDOH require `all' blood lead levels to be reported as soon as possible because they need to track blood lead levels among patients who had elevated blood lead levels in the past. If reporting facilities only report `elevat-

ed' results, then public health epidemiologists would not know if a patient who previously had `elevated' blood lead levels is now within the normal range. Since the injury rule states that only `elevated' blood levels are to be reported, most facilities only report `elevated' results.

2. Content Representation of Public Health Reporting Specifications based on Principles of Usability Testing:

i. Design of low-fidelity mock-ups:

We designed the representation of the reporting specifications for the following three scenarios:

a. Scenario 1: Multiple states all conditions

This view displayed the reporting specifications for all conditions in multiple jurisdictions. This particular view would be useful for a reporting facility that reports to multiple jurisdictions. For example, a reporting compliance officer from a reference laboratory or a hospital near a state border wants to know the laboratory reporting specifications for all diseases reportable in Colorado and Utah.

b. Scenario 2: One state all conditions

The view for this scenario displays the reporting specifications for reporting facilities wanting to identify all the reportable conditions in a particular jurisdiction. For example, an infection preventionist from a hospital wants to know the reporting specifications of all the diseases that should be reported by hospitals in Colorado.

c. Scenario 3: One state one condition

The view for this scenario displays the reporting specifications for reporting facilities wanting to identify if a specific event is reportable in a particular jurisdiction. For

example, a reporting personnel from a clinic wants to know the reporting specifications for Chlamydia trachomatis for Utah.

The display was designed to allow the users to obtain the views associated with each of the three scenarios independently by submitting separate queries or by navigating through the views from other scenarios. An example workflow is described below:

a. The user accesses the application and makes his or her selections based on their information need. Figure 3.4 displays the following query:

A. `Reporting Requirements for:' Laboratory

B. `Major Jurisdiction(s) of Interest:' Colorado, Utah, and Washington

C. `Reportable Event:' All

b. The user submits the query and a view that summarizes the laboratory reporting specifications for Colorado, Utah, and Washington is displayed to the user. This displays the `Multiple states all conditions' view for laboratories as shown in Figure 3.5. In this view, the user is displayed the reporting time frames and the requirement for specimen submission for diseases reportable in the specified jurisdictions.

c. The user obtains the reporting specifications for all reportable diseases for a specific jurisdiction by either submitting a new query or by clicking on the `plus icon' next to a specific jurisdiction (e.g., Utah). This displays the `One state all conditions' view for laboratories as shown in Figure 3.6. In this view, the user is displayed the reporting time frame, requirement for specimen submission, and the preferred method of reporting. Other methods of reporting are displayed only if the user clicks on the `plus icon'.

d. The user obtains the reporting specifications of a specific reportable disease (e.g., Chlamydia trachomatis) in a specific jurisdiction (e.g., Utah) by either submitting a new query or by clicking on the `plus icon' next to the disease. This displays the `One state one condition' view for laboratories as shown in Figure 3.7. In this view, the user is displayed the reporting action, the reporting criteria, and the references. The default display of the reporting criteria is the human-readable view of the laboratory findings. We based the display of the laboratory findings on the description in the CSTE Position Statements, but we also included the specimen source and the test status (preliminary or final).

e. The user obtains the reporting criteria including the list of relevant laboratory test names in LOINC and relevant test results in SNOMED-CT by clicking on the `plus icon'. A display of this view is shown in Figure 3.8.

ii. Usability testing with representatives from public health departments and reporting facilities:

The usability test sessions helped us identify the following additional requirements for the display of the reporting specifications:

a. Public health officials want the text to be changed from `Reporting Requirements for' to `I need Reporting Requirements for' to put the view in their specific context.

b. Public health officials want the query screen to include the capability of `Search' and not just `Select' for jurisdiction and reportable event. Including only a `Select' feature would require a pick-list that might be too long and cumbersome to use.

c. Public health officials want the `common name' for a reportable event to be included in the display (for example, whooping cough for pertussis, chicken pox for varicella)
d. Public health officials want the default view of the Laboratory findings to specify whether only positive test results are reportable or all test results are reportable.
e. Public health officials want the organism to be displayed in italics.
f. Public health officials want the link to the `National Notifiable Disease' information to be displayed under references.
g. Laboratories want to view the laboratory findings alone; they do not want to view the clinical constraints such as pregnancy status, diagnosis certainty, etc.
h. Laboratories want the system to have the capability of downloading the logic for the reporting criteria. Hence, requiring an `Export' button to be displayed so that they can download the file for use in their laboratory system.
i. Laboratories and clinical facilities want the system to have the capability to display only those reporting specifications that have been updated since a specific date.
j. Clinical facilities do not want to see the organisms that are associated with the reportable event. The designed view displayed the reportable event and the associated organism in parentheses.
k. Clinical facilities do not want to see the `LOINC and SNOMED-CT' mapping table for the reporting criteria.
l. Clinical facilities do not want to be displayed the requirements for specimen submission.
m. Clinical facilities want a link to the reporting forms.

n. All the users in the usability tests had different opinions on how the icon for `Specimen submission required' should be presented. We finally settled on a test-tube icon.
o. All the users wanted the `plus icon' to be displayed on the left of the text and not on the right of the text.
p. The system should use progressive disclosure. For example, all users only want the `Preferred' method of reporting to be displayed. The remaining methods of reporting should be displayed only if the user wants to view them.
q. Some users wanted the query screen to include a `Reset' button that would allow them to reset their selections to the default.

During and after the usability testing, the displays of the reporting specifications changed extensively. Figure 3.9 shows the final mock-up views of the query screen. Figures 3.10 and 3.11 show the final mock-up views of the `Multiple state all conditions' query result for laboratories and healthcare providers. Figures 3.12 and 3.13 show the final mock-up views of the ‘One state all conditions’ query result for Utah for laboratories and healthcare providers. Figures 3.14 and 3.15 show the final mock-up views of the `One state one condition' query result for laboratories and healthcare providers. Figures 3.16 and 3.17 show the views of the `One state one condition' query result for laboratories with the expanded `LOINC and SNOMED-CT mappings' and 'References'.

Discussion

Public health reporting specifications are published in each public health department's Website. This makes it difficult for reporting facilities to identify the `what', the `where', the `when`, and the `how' of reporting. In this chapter, we focused on identifying

the content required to define public health reporting specifications and determined how to represent the content to meet the users' needs.

Content analysis of public health reporting specifications

During the review of the reporting specifications for Colorado, Utah, and Washington, we identified variation in (a) reporting time frame across jurisdictions, (b) reporting time frames within a jurisdiction across types of reporting facilities, (c) criteria used to determine the responsible health department, and (d) the set of events reportable across jurisdictions. We did not find any literature describing the first three variations. However, a study conducted by Jajosky et al. using data from all 50 states showed that of 93 reportable events, only 39 (46\%) were reportable in all 50 states [4]. We found that of the 82 reportable events in Colorado, Utah, and Washington, 56\% were reportable in all three states. We also found that 58 events were reportable in both Colorado and Utah, whereas Colorado and Washington had 48 common reportable events and Utah and Colorado had 48 common reportable events. The proximity in geographical location may explain the similarity in the conditions reportable in Colorado and Utah.

We identified that the patient's address, ordering facility address, address of the facility collecting the specimen, and the diagnostic facility address were needed to identify the jurisdiction responsible for the reportable events. We reviewed the HL7 v2.5.1 implementation guide for Electronic Laboratory Reporting (ELR) to public health that was made available in 2010 [21] to determine if the guide included the data elements needed to identify the responsible jurisdiction. We found that the guide included the patient's address, ordering facility address, and diagnostic facility address in the PID, ORC, and OBX segments respectively. However, it did not include the address of the facility col-

lecting the specimen, which is needed to determine the jurisdiction responsible for the reported events in Colorado. There are other concepts that can be used to determine the responsible jurisdiction. The CSTE Surveillance Practice and Implementation Subcommittee are currently (as in May 2012) involved with determining the concepts to establish residency. It will be important to ensure that the required data elements are included in standards for electronic messaging.

The review of the blood lead level reporting criteria in Colorado, Utah, and Washington showed that there was variation in the blood lead levels, patient's age, and reporting time-frame. This indicates that evidence-based reasoning may not be used to define the reporting criteria. Some variation in the reporting specifications is required (for example, during an outbreak, some states may require reports on preliminary as well as final results, or they may add a new reportable event (e.g., H1N1) or a new laboratory test). However, we believe variation in public health reporting specifications have also come about because the specifications have been developed independently by different jurisdictions and hence reflect the preferences and needs of public health authorities at the time the specifications were published.

Trying to accommodate variation in automated systems for reporting facilities that need to report to multiple jurisdictions may not be efficient or essential to meet evidence-based needs. As shared systems become more prevalent, there is a need to standardize the specifications. The Position Statements are an attempt to standardize the specifications for nationally notifiable conditions but they do not address the existing variation in reporting time frames for reporting from a clinical or laboratory setting.

Past studies have shown that public health departments routinely update the reporting specifications in their jurisdictions [2]. The research described in this chapter identified similar findings. For example, in Spring 2010, when we reviewed the reporting specifications for Utah, Influenza-associated hospitalization was reportable only if the patient was hospitalized for more than 24 hours. However, as of today (March 2012), the requirement for `24 hours hospitalization' has been removed. Thus, the ongoing updating of reporting requirements demonstrates a need for a knowledge management system for reporting specifications that can be authored, maintained by public health authorities, and shared with reporting facilities.

The content analysis that we conducted has limitations. First, the content analysis was based on the reporting specifications in only three states: Colorado, Utah, and Washington. Since reporting specifications may also vary by geographic location of the states, we recommend that a similar analysis be conducted with a wider sample of states in the United States. However, the results from Jajosky et al. based on the 50 states also found a similar variation in the set of events that were reportable in each state.

Second, the findings from the interviews were based on input from two epidemiologists from the UDOH. Since, the reporting specifications vary by event and jurisdiction, we recommend that input is obtained from a larger group of public health epidemiologists from multiple jurisdictions to validate the content using users representing a wider range of states and handling a variety of diseases.

Content representation of public health reporting specifications

The content representation involved several usability sessions with representatives from public health departments, laboratories, and clinical facilities. We found that each

type of user had different requirements for the displays, thus confirming that user-input from all stakeholders is essential to system design.

The content representation has limitations. One limitation relates to the services that can be supported by the views we identified. Users from reporting facilities expect a knowledge management system for public health reporting specifications to include the following high-level services:

1. Enable the user to identify the responsible health department for a specific case.
2. Enable the user to identify the conditions reportable in specific jurisdictions and the relevant reporting specifications such as the reporting time frame, methods of reporting, etc. This service assumes that the reporting facility is looking for the reporting requirements in specific jurisdictions.

The first service would allow a reporting facility to identify the responsible jurisdiction based on the patient's address, the ordering facility, etc. The second service assumes that the reporting facility knows the specific jurisdiction and wants the reporting specifications for that jurisdiction. The views identified in the study can be used to provide the second service and not the first service.

The second limitation of the methods used to identify the content representation is that we used low-fidelity mock-up of the designed displays. Since the views were not interactive, the design in its current form may not meet the users' needs of an interactive system. We recommend that usability evaluation be conducted once a web-based system for public health reporting specifications is developed.

In conclusion, we have defined the reporting specifications for public health reporting using user-input and our findings will be useful in the development of public

health knowledge management systems that define reporting specifications for laboratories and clinical facilities.

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21 HL7 version 2.5.1 implementation guide: Electronic laboratory reporting to public health*, Release 1* (US Realm). Health Level Seven, International. 2010.

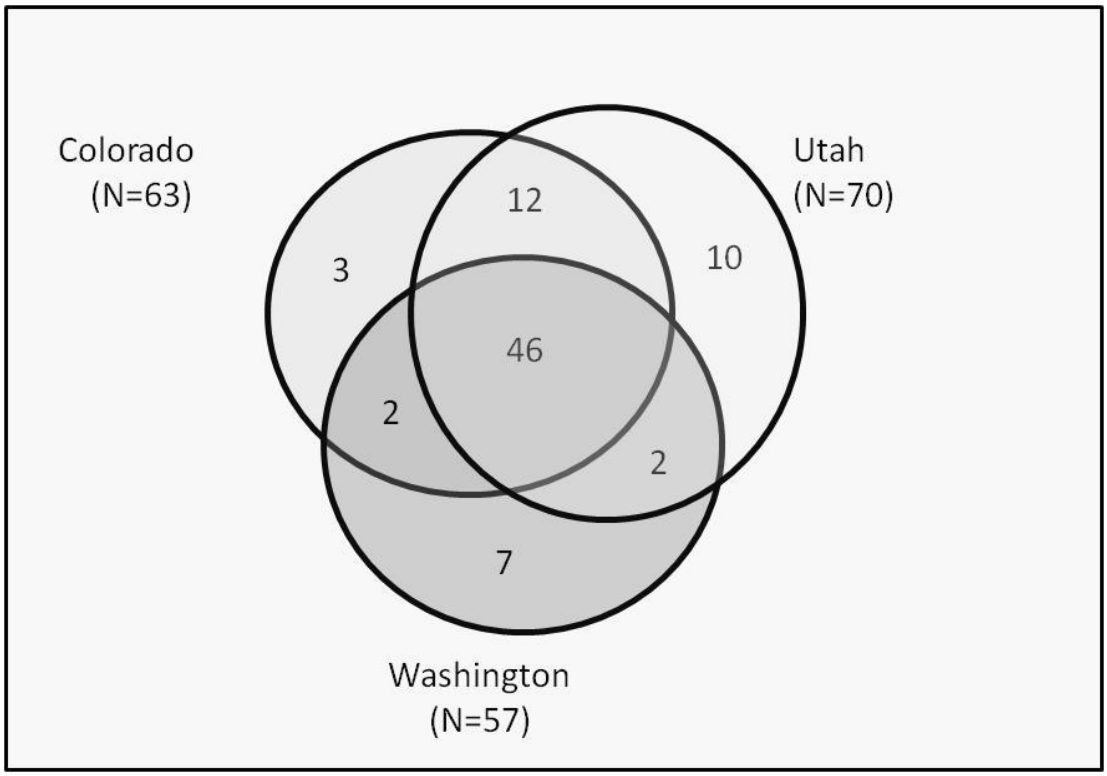


Figure 3.1: Distribution of overlap between the 82 events specified in the reportable disease lists in Colorado, Utah, and Washington in 2010.

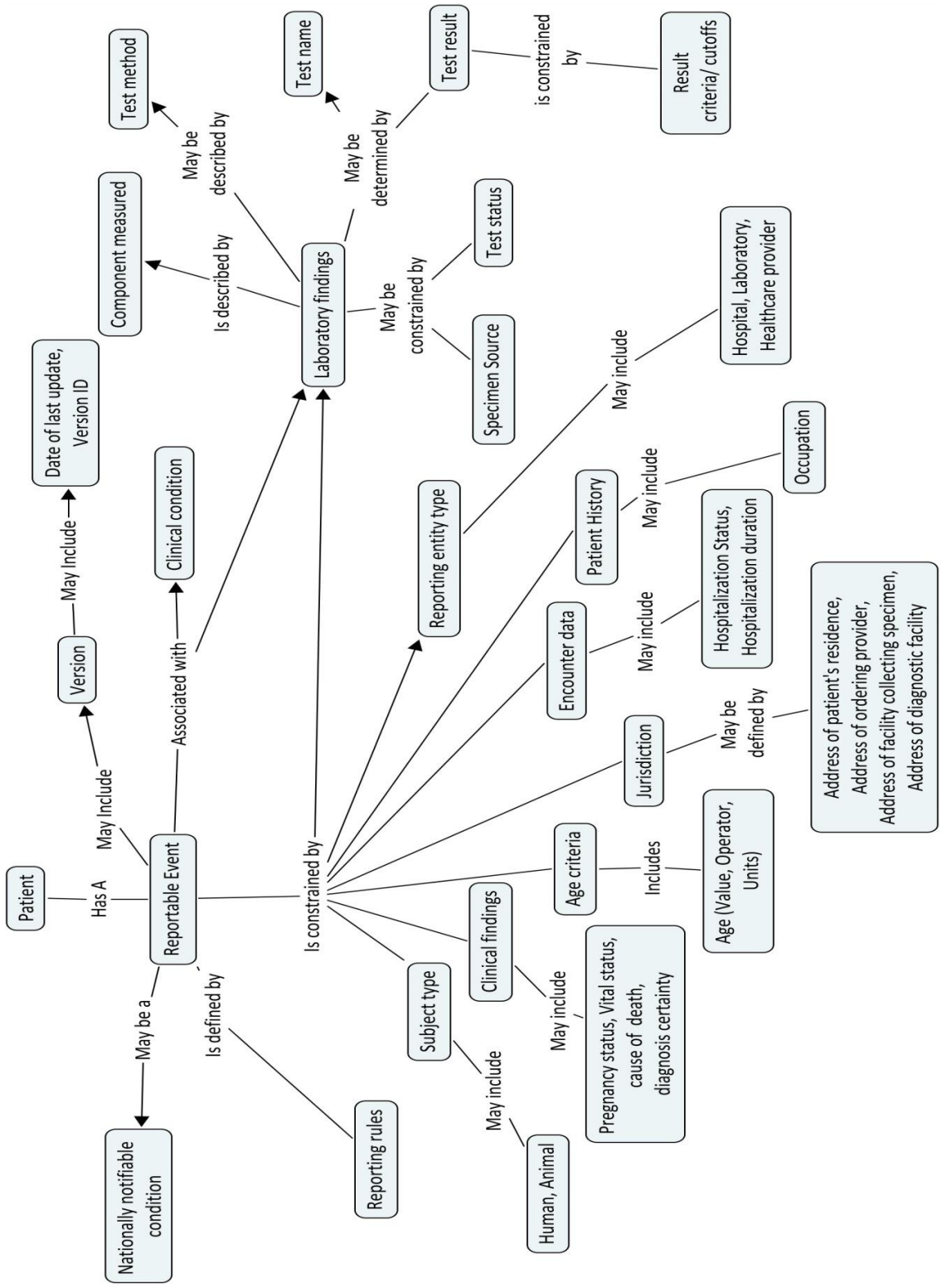


Figure 3.2 Concepts associated with the reportable event

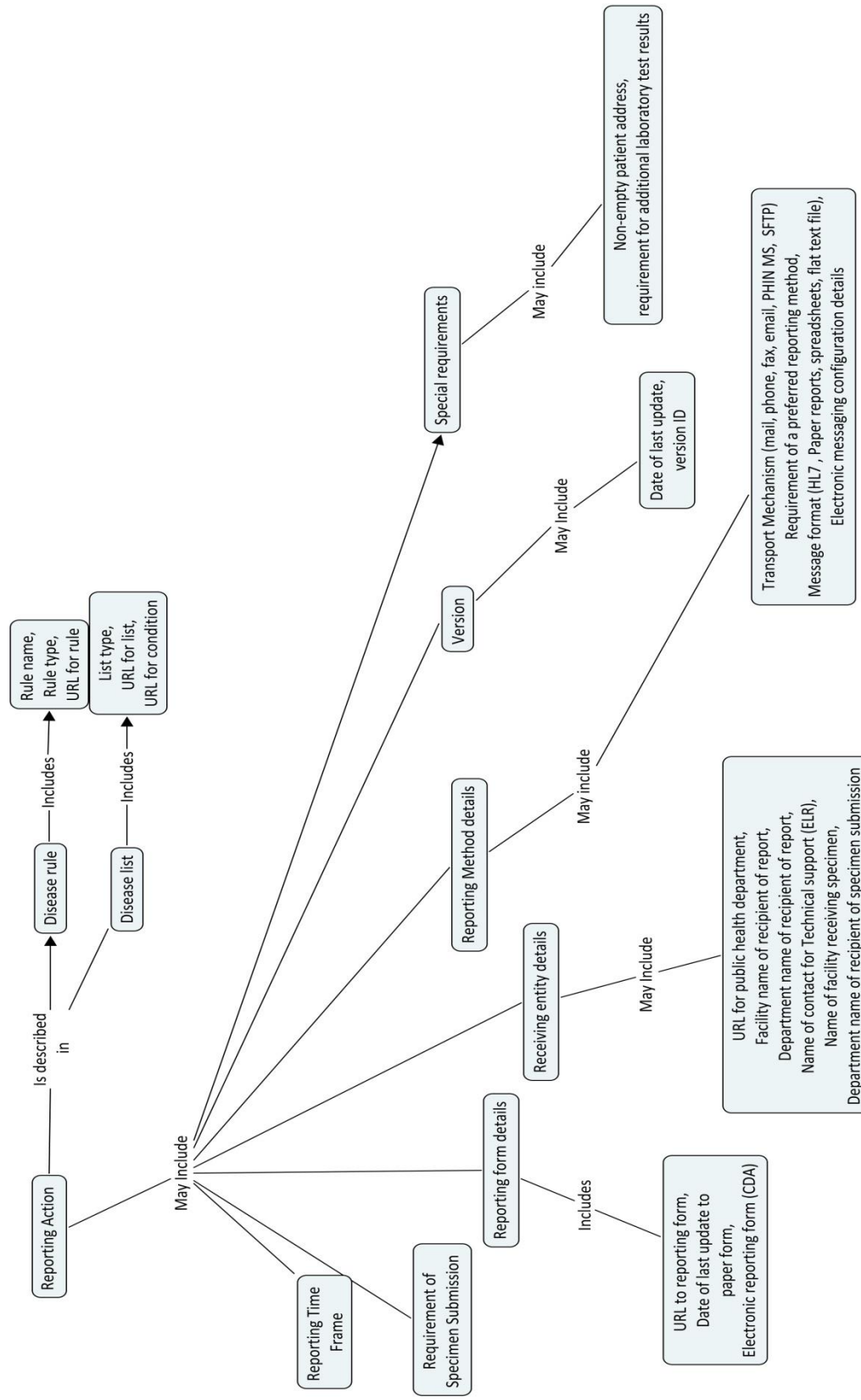


Figure 3.3 Concepts associated with the reporting action

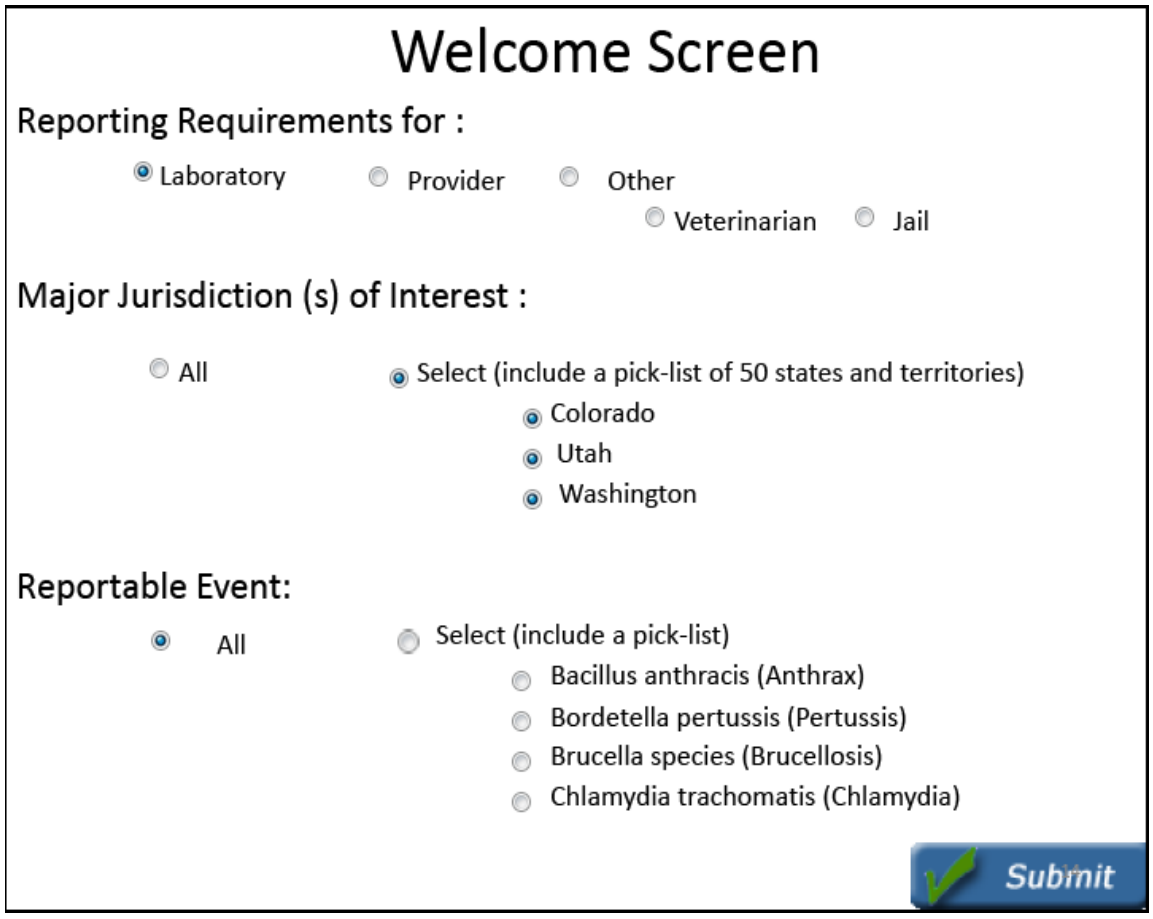


Figure 3.4: Display of the 'Query screen' before performing usability testing

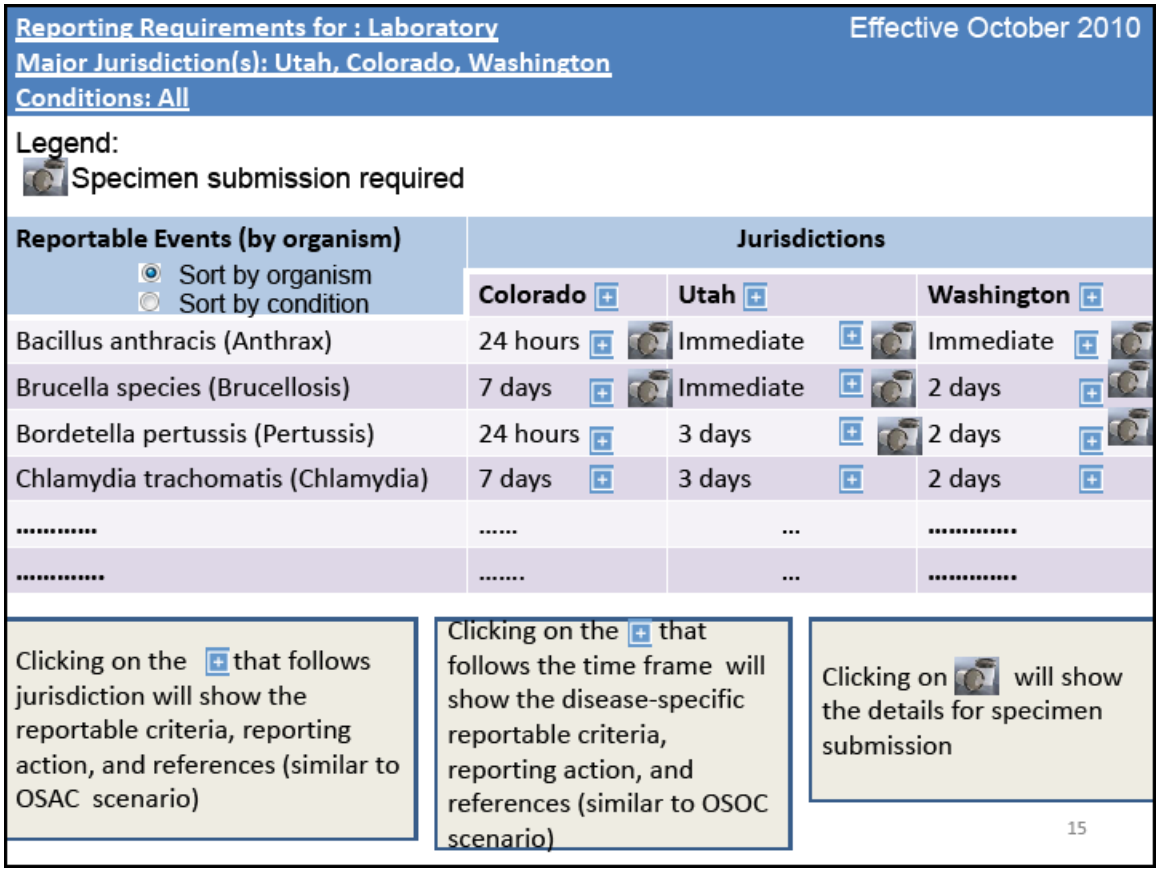


Figure 3.5: Display of the 'Multiple states all conditions' query result before performing usability testing

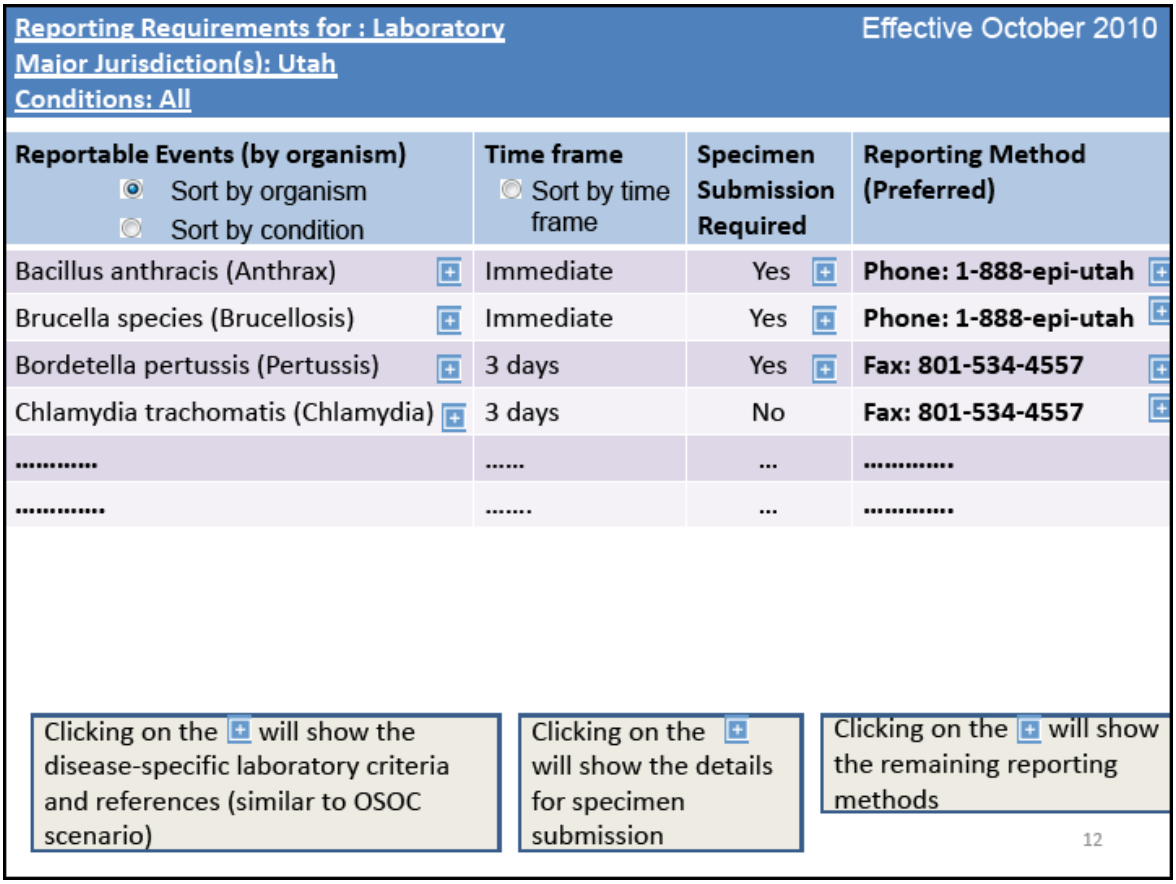
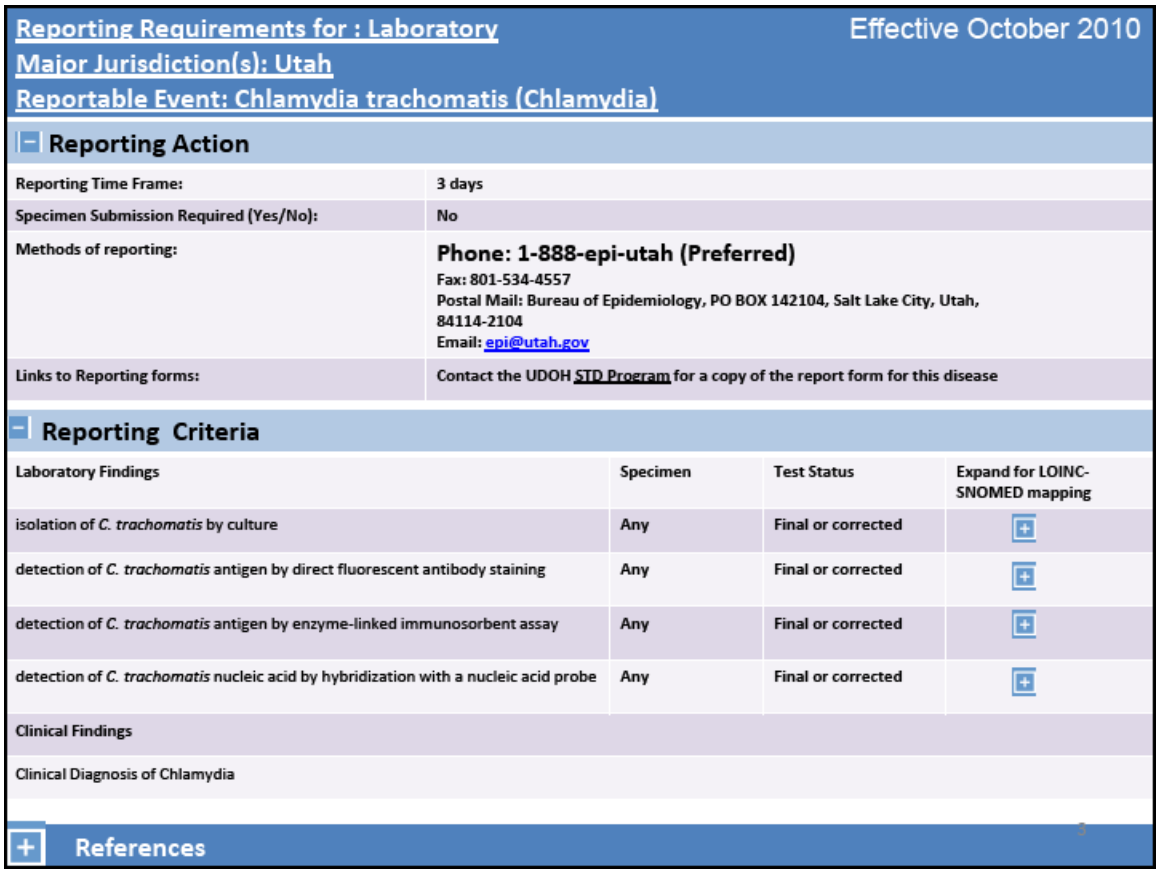


Figure 3.6: Display of the 'One state all conditions' query result before performing usability testing



Reporting Requirements for : Laboratory — Effective October 2010
Major Jurisdiction(s): Utah
Reportable Event: Chlamydia trachomatis (Chlamydia)

Reporting Action

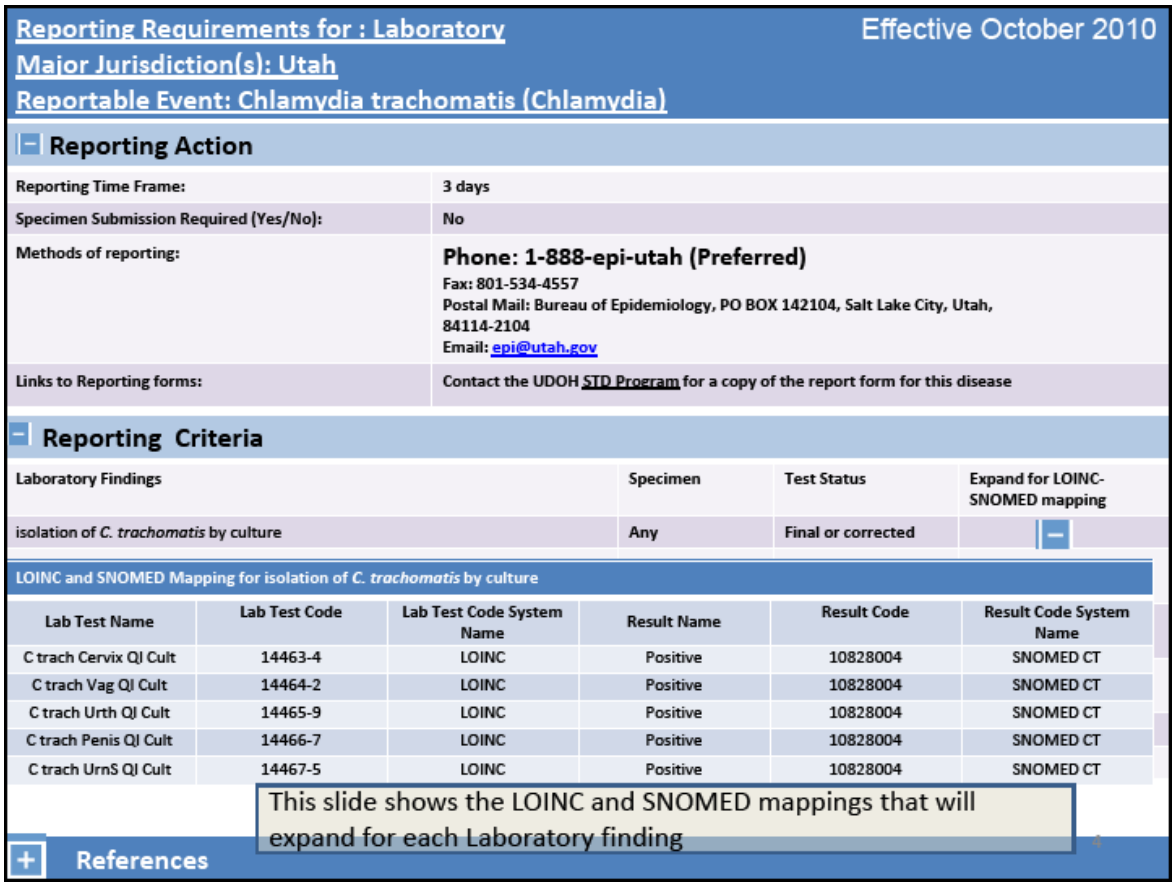
Reporting Time Frame:	3 days
Specimen Submission Required (Yes/No):	No
Methods of reporting:	**Phone: 1-888-epi-utah (Preferred)** Fax: 801-534-4557 Postal Mail: Bureau of Epidemiology, PO BOX 142104, Salt Lake City, Utah, 84114-2104 Email: epi@utah.gov
Links to Reporting forms:	Contact the UDOH STD Program for a copy of the report form for this disease

Reporting Criteria

Laboratory Findings	Specimen	Test Status	Expand for LOINC-SNOMED mapping
isolation of *C. trachomatis* by culture	Any	Final or corrected	
detection of *C. trachomatis* antigen by direct fluorescent antibody staining	Any	Final or corrected	
detection of *C. trachomatis* antigen by enzyme-linked immunosorbent assay	Any	Final or corrected	
detection of *C. trachomatis* nucleic acid by hybridization with a nucleic acid probe	Any	Final or corrected	
Clinical Findings			
Clinical Diagnosis of Chlamydia			

References

Figure 3.7: Display of the 'One state one condition' query result before performing usability testing



Reporting Requirements for : Laboratory — Effective October 2010
Major Jurisdiction(s): Utah
Reportable Event: Chlamydia trachomatis (Chlamydia)

Reporting Action

Reporting Time Frame:	3 days
Specimen Submission Required (Yes/No):	No
Methods of reporting:	**Phone: 1-888-epi-utah (Preferred)** Fax: 801-534-4557 Postal Mail: Bureau of Epidemiology, PO BOX 142104, Salt Lake City, Utah, 84114-2104 Email: epi@utah.gov
Links to Reporting forms:	Contact the UDOH STD Program for a copy of the report form for this disease

Reporting Criteria

Laboratory Findings	Specimen	Test Status	Expand for LOINC-SNOMED mapping
isolation of *C. trachomatis* by culture	Any	Final or corrected	

LOINC and SNOMED Mapping for isolation of *C. trachomatis* by culture

Lab Test Name	Lab Test Code	Lab Test Code System Name	Result Name	Result Code	Result Code System Name
C trach Cervix QI Cult	14463-4	LOINC	Positive	10828004	SNOMED CT
C trach Vag QI Cult	14464-2	LOINC	Positive	10828004	SNOMED CT
C trach Urth QI Cult	14465-9	LOINC	Positive	10828004	SNOMED CT
C trach Penis QI Cult	14466-7	LOINC	Positive	10828004	SNOMED CT
C trach UrnS QI Cult	14467-5	LOINC	Positive	10828004	SNOMED CT

This slide shows the LOINC and SNOMED mappings that will expand for each Laboratory finding

References

Figure 3.8: Display of the 'One state one condition' query result with expanded LOINC and SNOMED-CT mappings before performing usability testing

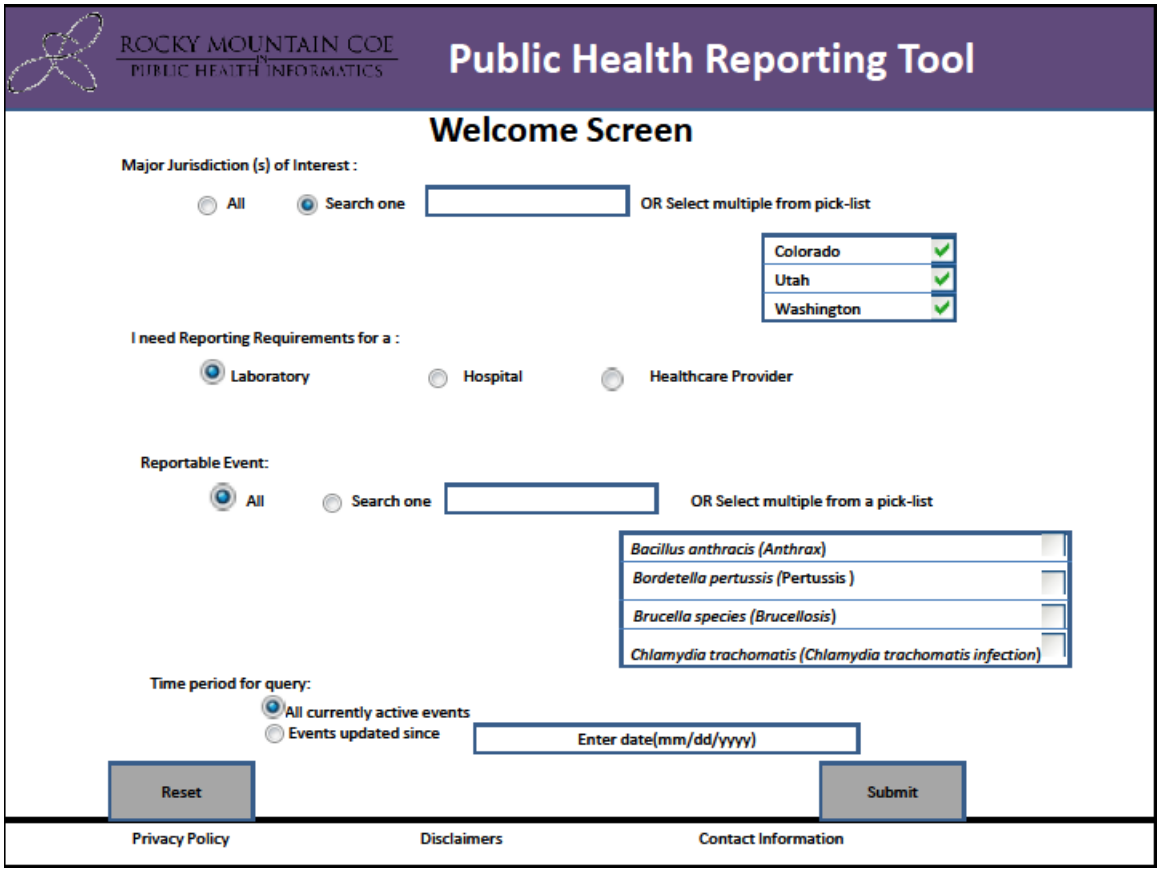


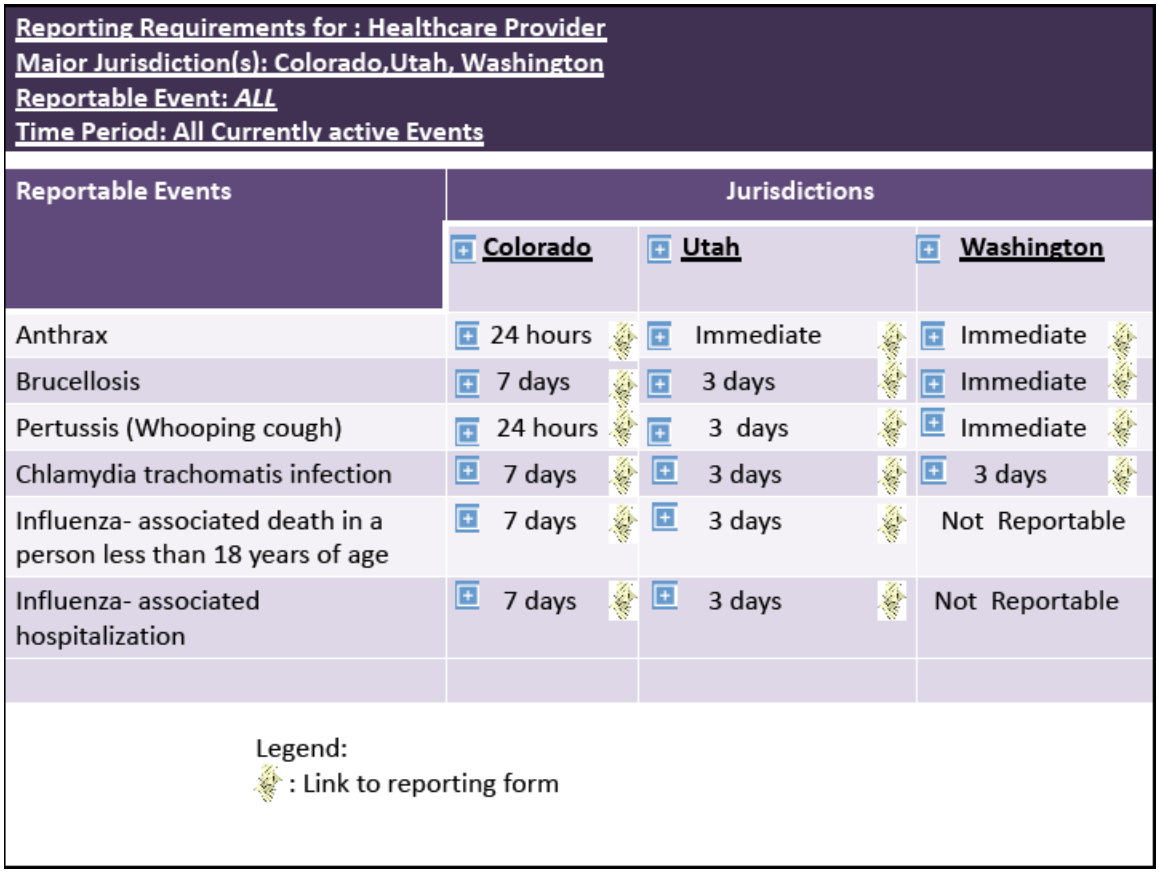
Figure 3.9: Display of the 'Query screen' after performing usability testing

Reporting Requirements for : Laboratory
Major Jurisdiction(s): Colorado,Utah, Washington
Reportable Event: *ALL*
Time Period: All Currently active Events

Reportable Events (by organism)	Jurisdictions		
	Colorado	**Utah**	**Washington**
Bacillus anthracis (Anthrax)	24 hours	Immediate	Immediate
Brucella species (Brucellosis)	7 days	3 days	2 days
Bordetella pertussis (Pertussis) (Whooping cough)	24 hours	3 days	2 days
Chlamydia trachomatis (Chlamydia) trachomatis infection	7 days	3 days	2 days
Influenza virus (Influenza-associated death in a person less than 18 years of age)	Not Reportable	3 days	Not Reportable
Influenza virus (Influenza-associated hospitalization)	Not Reportable	3 days	Not Reportable

Legend:
: Specimen submission required

Figure 3.10: Laboratory view-'Multiple states all conditions' query result after performing usability testing



Reporting Requirements for : Healthcare Provider
Major Jurisdiction(s): Colorado,Utah, Washington
Reportable Event: *ALL*
Time Period: All Currently active Events

Reportable Events	Jurisdictions		
	Colorado	Utah	Washington
Anthrax	24 hours	Immediate	Immediate
Brucellosis	7 days	3 days	Immediate
Pertussis (Whooping cough)	24 hours	3 days	Immediate
Chlamydia trachomatis infection	7 days	3 days	3 days
Influenza- associated death in a person less than 18 years of age	7 days	3 days	Not Reportable
Influenza- associated hospitalization	7 days	3 days	Not Reportable

Legend:
: Link to reporting form

Figure 3.11: Healthcare provider view-'Multiple states all conditions' query result after performing usability testing

Reporting Requirements for : Laboratory
Major Jurisdiction(s): Utah
Reportable Event: *ALL*
Time Period: All Currently active Events

Reportable Events (by organism)	Time frame (Sort by time frame)	Specimen Submission Required	Reporting Method (Preferred)
Bacillus anthracis (Anthrax)	Immediate	Yes	**Phone: 1-888-epi-utah**
Brucella species (Brucellosis)	3 days	Yes	**Fax: 801-534-4557**
Bordetella pertussis (Pertussis) (Whooping cough)	3 days	Yes	**Fax: 801-534-4557**
Chlamydia trachomatis (Chlamydia trachomatis infection)	3 days	No	**Fax: 801-534-4557**
Influenza virus (Influenza-associated hospitalization)	3 days	Yes	**Fax: 801-534-4557**
Influenza virus (Influenza-associated death in a person less than 18 years of age)	3 days	Yes	**Fax: 801-534-4557**

Figure 3.12: Laboratory view- ‘One state all conditions (Utah) query result after performing usability testing

Reporting Requirements for : Healthcare Provider
Major Jurisdiction(s): Utah
Reportable Event: *ALL*
Time Period: All Currently active Events

Reportable Events	Time frame Sort by time frame	Link to Reporting Form	Reporting Method (Preferred)
Anthrax	Immediate	http://health.utah.gov/epi/disease_plans_forms_factsheets.html	**Phone: 1-888-epi-utah**
Brucellosis	3 days	.....	**Fax: 801-534-4557**
Pertussis (Whooping cough)	3 days	.....	**Fax: 801-534-4557**
Chlamydia Trachomatis Infection	3 days	.....	**Fax: 801-534-4557**
Influenza-associated hospitalization	3 days	.....	**Fax: 801-534-4557**
Influenza-associated death in a person less than 18 years of age	3 days	.....	**Fax: 801-534-4557**

Figure 3.13: Healthcare provider view-'One state all conditions' (Utah) query result after performing usability testing

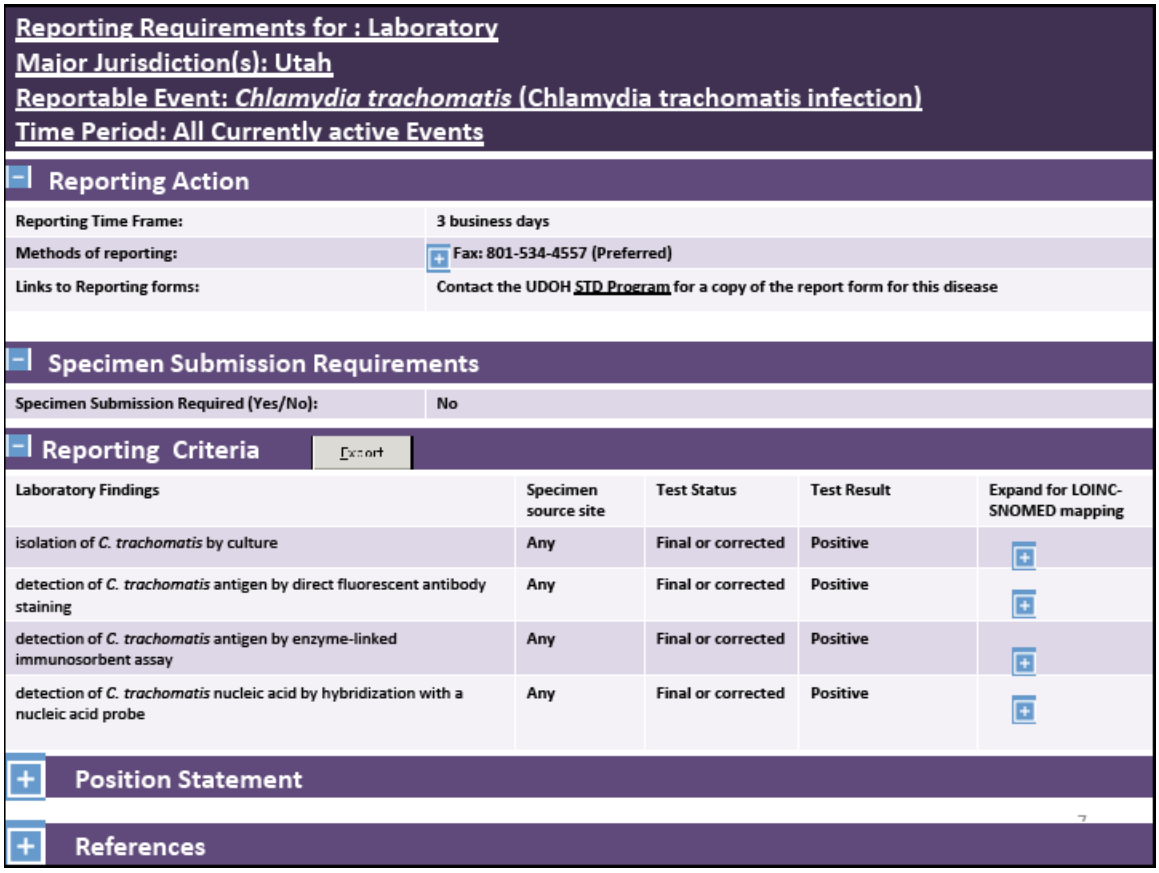
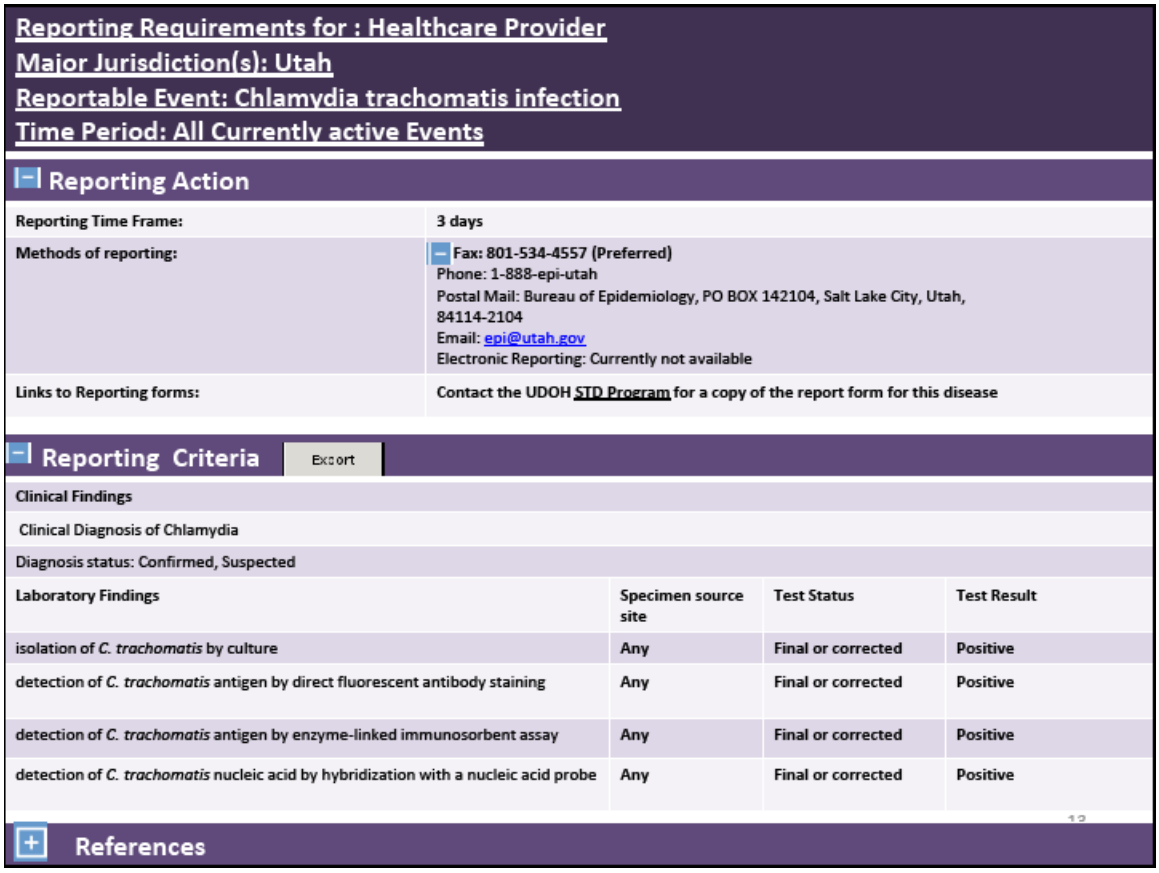


Figure 3.14: Laboratory view-'One state one condition (Utah, Chlamydia trachomatis) query result after performing usability testing



Reporting Requirements for : Healthcare Provider
Major Jurisdiction(s): Utah
Reportable Event: Chlamydia trachomatis infection
Time Period: All Currently active Events

Reporting Action

Reporting Time Frame:	**3 days**
Methods of reporting:	**Fax: 801-534-4557 (Preferred)** Phone: 1-888-epi-utah Postal Mail: Bureau of Epidemiology, PO BOX 142104, Salt Lake City, Utah, 84114-2104 Email: epi@utah.gov Electronic Reporting: Currently not available
Links to Reporting forms:	**Contact the UDOH STD Program for a copy of the report form for this disease**

Reporting Criteria Export

Clinical Findings

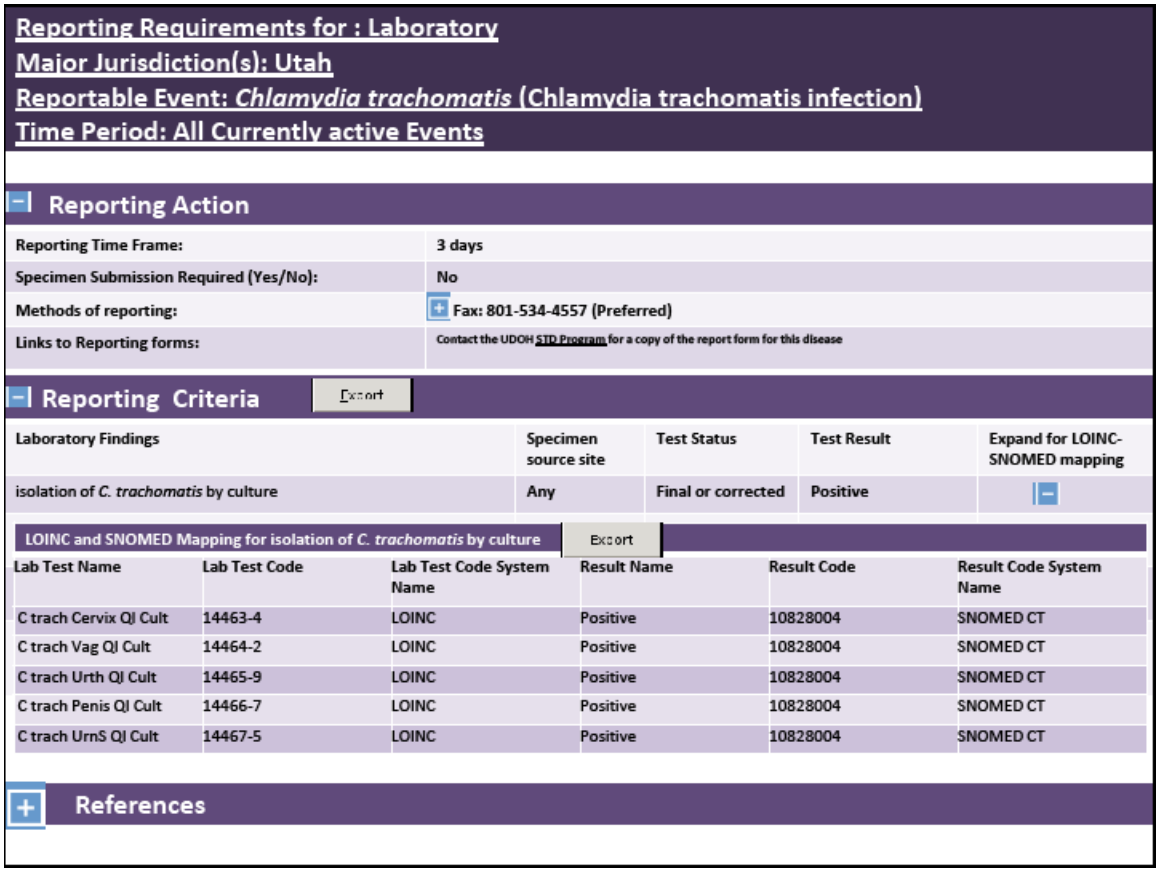
Clinical Diagnosis of Chlamydia

Diagnosis status: Confirmed, Suspected

Laboratory Findings	Specimen source site	Test Status	Test Result
isolation of *C. trachomatis* by culture	Any	Final or corrected	Positive
detection of *C. trachomatis* antigen by direct fluorescent antibody staining	Any	Final or corrected	Positive
detection of *C. trachomatis* antigen by enzyme-linked immunosorbent assay	Any	Final or corrected	Positive
detection of *C. trachomatis* nucleic acid by hybridization with a nucleic acid probe	Any	Final or corrected	Positive

References

Figure 3.15: Healthcare provider view-'One state one condition' (Utah, Chlamydia trachomatis infection) query result after performing usability testing



Reporting Requirements for : Laboratory
Major Jurisdiction(s): Utah
Reportable Event: *Chlamydia trachomatis* (Chlamydia trachomatis infection)
Time Period: All Currently active Events

Reporting Action

Reporting Time Frame:	3 days
Specimen Submission Required (Yes/No):	No
Methods of reporting:	Fax: 801-534-4557 (Preferred)
Links to Reporting forms:	Contact the UDOH STD Program for a copy of the report form for this disease

Reporting Criteria Export

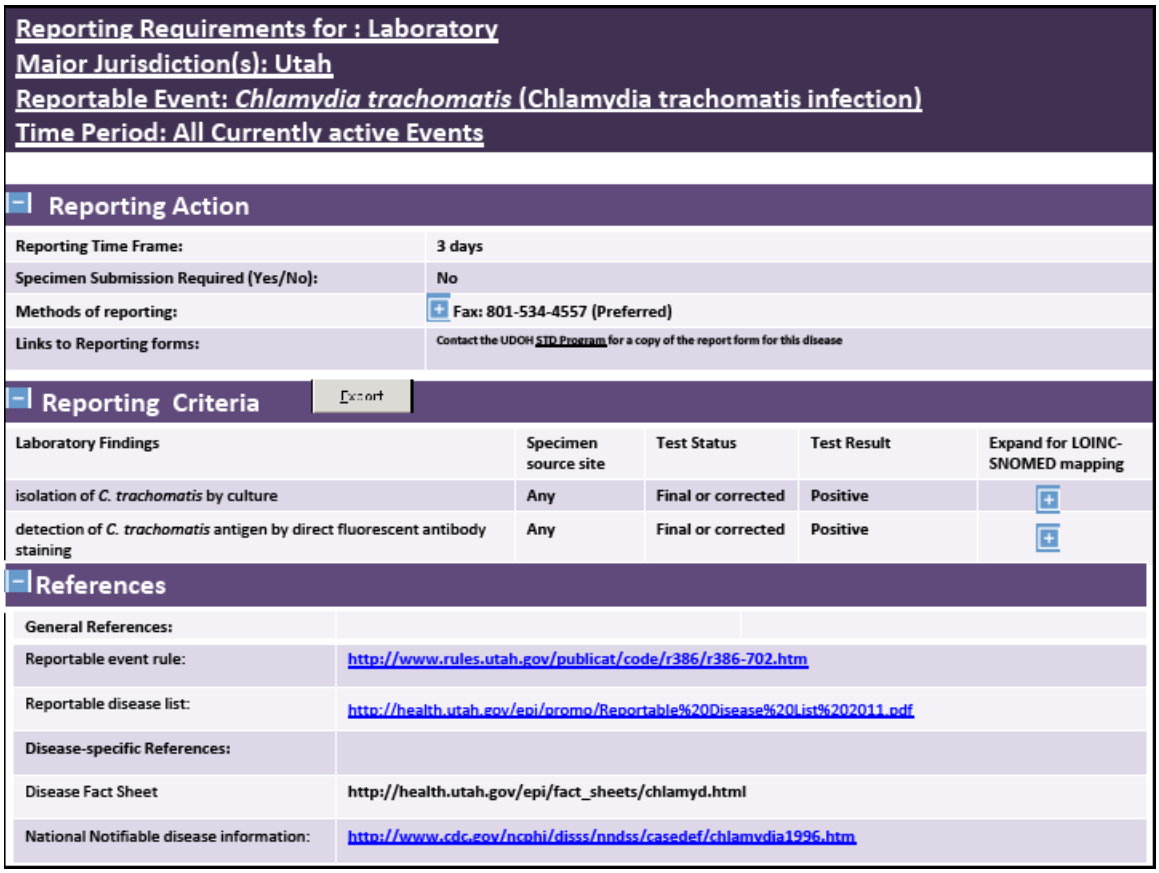
Laboratory Findings	Specimen source site	Test Status	Test Result	Expand for LOINC-SNOMED mapping
isolation of *C. trachomatis* by culture	Any	Final or corrected	Positive	

LOINC and SNOMED Mapping for isolation of *C. trachomatis* by culture Export

Lab Test Name	Lab Test Code	Lab Test Code System Name	Result Name	Result Code	Result Code System Name
C trach Cervix Ql Cult	14463-4	LOINC	Positive	10828004	SNOMED CT
C trach Vag Ql Cult	14464-2	LOINC	Positive	10828004	SNOMED CT
C trach Urth Ql Cult	14465-9	LOINC	Positive	10828004	SNOMED CT
C trach Penis Ql Cult	14466-7	LOINC	Positive	10828004	SNOMED CT
C trach UrnS Ql Cult	14467-5	LOINC	Positive	10828004	SNOMED CT

References

Figure 3.16: Laboratory view-'One state one condition' query result with expanded LOINC-SNOMED mappings after performing usability testing



Reporting Requirements for : Laboratory
Major Jurisdiction(s): Utah
Reportable Event: *Chlamydia trachomatis* (Chlamydia trachomatis infection)
Time Period: All Currently active Events

Reporting Action

Reporting Time Frame:	3 days
Specimen Submission Required (Yes/No):	No
Methods of reporting:	Fax: 801-534-4557 (Preferred)
Links to Reporting forms:	Contact the UDOH STD Program for a copy of the report form for this disease

Reporting Criteria

Export

Laboratory Findings	Specimen source site	Test Status	Test Result	Expand for LOINC-SNOMED mapping
isolation of *C. trachomatis* by culture	Any	Final or corrected	Positive	
detection of *C. trachomatis* antigen by direct fluorescent antibody staining	Any	Final or corrected	Positive	

References

General References:	
Reportable event rule:	http://www.rules.utah.gov/publicat/code/r386/r386-702.htm
Reportable disease list:	http://health.utah.gov/epi/promo/Reportable%20Disease%20List%202011.pdf
Disease-specific References:	
Disease Fact Sheet	http://health.utah.gov/epi/fact_sheets/chlamyd.html
National Notifiable disease information:	http://www.cdc.gov/ncphi/disss/nndss/casedef/chlamydia1996.htm

Figure 3.17: Laboratory view-'One state one condition' query result with expanded references after performing usability testing

Table 3.1: Reporting time frames based on reportable disease lists published in Colorado, Utah, and Washington (Spring 2010)

		Reporting time frames					
	Type of reporting facility	Immediately	24 hours	2 days	3 days	7 days	Monthly
Colorado	Laboratories		✓			✓	
	Hospitals		✓			✓	
	Providers		✓			✓	
Utah	Laboratories	✓			✓		
	Hospitals	✓			✓		
	Providers	✓			✓		
Washington	Laboratories	✓		✓			✓
	Hospitals	✓			✓		✓
	Providers	✓			✓		✓

Table 3.2: Criteria used to identify the jurisdiction responsible for reportable events in Colorado, Utah, and Washington (Spring 2010)

	Patient's Home Address	Address of Ordering Facility	Address of Facility collecting the specimen	Address of Diagnostic Facility
Colorado			✓	✓
Utah	Not explicitly			
Washington	✓	✓		

Table 3.3: Variation in the public health reporting requirements identified within and between Colorado, Utah, and Washington in 2010

S.No	Findings	Example
1.	Reportable Events have different reporting time frames in a single jurisdiction based on the type of reporting facility.	In Washington, Listeriosis was reportable immediately by clinical facilities but was reportable within 2 days by laboratories.
2.	Reportable Events have varied levels of urgency of reporting in different jurisdictions.	The reporting time frame for Brucellosis for healthcare providers was 7 days in Colorado, 3 days in Utah, and immediately in Washington.
3.	Reportable events are not clinical conditions.	The clinical condition 'influenza' is associated with two reportable events: 'Influenza-associated death in a person less than 18 years of age' and 'Influenza-associated hospitalization', both of which are reportable in Colorado an Utah.
4.	In some jurisdictions, the reporting criteria are constrained by: the patient's age.	Haemophilus influenzae (invasive disease) was reportable in Washington only if the patient is under 5 years of age, whereas there was no age constraint in Colorado and Utah. Hemolytic uremic syndrome was reportable in Colorado only if the patient was less than 18 years old, whereas there was no age constraint in Utah and Washington.
5.	In some jurisdictions, the reporting criteria are constrained by: the patient's pregnancy status.	Hepatitis B (positive surface antigen) was reportable in Washington by laboratories and clinical facilities only if the patient was pregnant, whereas both Utah and Colorado did not explicitly specify this constraint.
6.	In some jurisdictions, the reporting criteria are constrained by: the patient's hospitalization status and hospitalization duration.	Influenza-associated hospitalization was reportable in Utah only if the patient had been hospitalized for more than 24 hours.

Table 3.4: Reporting criteria for blood lead level in Utah, Colorado, and Washington (Spring 2010)

Relevant Jurisdiction	Blood lead level	Patient's age	Reporting time-frame
Colorado	≥10μg/dL	≤ 18 years	7 working days
	<10μg/dL	≤ 18 years	30 days
	≥25μg/dL	> 18 years	30 days
	<25μg/dL	> 18 years	No action
Utah	≥10μg/dL	Any	60 days
	<10μg/dL	Any	No action
Washington	≥10μg/dL	≤ 15 years	2 working days
	<10μg/dL	≤ 15 years	1 month
	≥25μg/dL	Any	2 working days
	<25μg/dL	> 15 years	1 month

CHAPTER 4

USABILITY EVALUATION OF A WEB-BASED SYSTEM FOR PUBLIC HEALTH REPORTING SPECIFICATIONS

Background

Reporting facilities such as laboratories, hospitals, and healthcare providers are mandated to report certain events to public health entities. Currently, public health reporting specifications are published as `reportable disease lists and rules' on individual public health department websites and posters [1]. Facilities that need to report to multiple jurisdictions find it challenging to keep track of the various reporting specifications.

The public health community recognizes that it needs a consolidated resource to specify which diseases are reportable in each jurisdiction. To this end, the Council of State and Territorial Epidemiologists (CSTE) conduct an annual assessment of conditions reportable in all states in the US and present these results using a web-based data query system [2, 3]. However, the current version of the SRCA tool cannot be used by laboratories and clinical facilities as a single resource for public health specifications for several reasons. First, it does not include all jurisdictions. Second, it is updated only once a year and therefore may not always include the most active reporting specifications. Third, it does not capture information needed by reporting facilities to report events to public health authorities such as the reporting time frame and the reporting methods (e.g., phone, fax, etc.). Fourth, the reporting specifications for various states are not based on

standards and are not provided in a format that is machine readable; making it difficult for reporting facilities to use the data for automated detection of reportable conditions [3]. Hence, there is still a requirement for a web-based public health reporting system that meets the needs of the reporting facilities. We have conducted research to model the reporting specifications based on user-defined needs. In continuation of this research, we developed a prototype web-based system for public health reporting specifications as a collaborative effort between the University of Utah and the Utah Department of Health (UDOH).

Design and Development

During the design and development of the web application, we collaborated with a software programmer from the UDOH and an information architect from the University of Utah.

The public health reporting knowledge was stored using XML [4]. The system design included an XML Schema for the following assets: reportable event, reporting action, specimen submission action, reporting criteria, references, and receiving business unit. The design included a common XML header for all assets but the XML body varied for each type of asset. The header included the relevant context for the knowledge. For example, the relevant jurisdiction is specified as a state in the spatial context field and the type of reporting facility (laboratory, hospital, and healthcare provider) is specified in the role context field. A description of additional elements in the header and the XML body for each asset is given below:

1. Reportable Event: The XML header for the reportable event also includes the name of the reportable event and the topical context that specifies the clinical condition and

the laboratory finding. The XML body includes links to XML documents relating to the reporting criteria, reporting action, specimen submission action, and references.

2. Reporting Action: The XML body for the reporting action includes the reporting time frame (number, units, and interpretation) and the link to the XML for the receiving business unit.
3. Specimen Submission Action: The XML body for the specimen submission action includes links to the XML document for the appropriate receiving business unit.
4. Reporting Criteria: The XML header for the reporting criteria also includes the topical context to specify the clinical condition and the laboratory finding. The XML body includes information regarding the laboratory test name, the laboratory test result, the requirement for preliminary or final results, and the requirement for `only positive results' or `all results'.
5. References: The XML body for the references includes the reference type (reportable disease list, state rule, etc), the name of the reference, and the relevant URL.
6. Receiving Business Unit: The XML body for the receiving business unit includes the type of business unit (public health department or state laboratory for specimen submission), the name of the receiving business unit, the department, the mailing address, the physical address, and the methods of reporting (including an indicator to specify if the reporting method was the preferred method of reporting).

The web-based system was developed using JAVA [5] and uses the infrastructure developed for the University of Utah's Federated Utah Research and Translational Health e-Repository (FURTHeR) [6]. The XML documents are stored in a metadata repository of FURTHeR. The terminology services are handled by Apelon's Distributed Terminolo-

gy System [7]. To support the software programmer to develop the system, we compiled test cases for the views of the Query screen, the `Multiple state all conditions', the `One state all conditions', and the `One state one condition' (described in Chapter 3). The test case for the Query screen can be found in Appendix D. During the development process, we conducted QA tests and the iterative QA process involved testing the web-based system, documenting the problems that we identified, and communicating our findings with the software programmer.

Studies have shown that evaluating the usability of a system prior to implementation is essential to improve system adoption among users [8, 9]. Therefore, in this chapter, we describe the research conducted to evaluate the usability of the web-application for public health reporting specifications.

Objectives

The research described in this chapter had two main objectives:

1. Describe the business process for a laboratory to comply with reporting requirements.
2. Identify problems faced by reporting facilities when accessing reporting specifications communicated on public health department web sites.

Methods

To meet the objectives of the research outlined in this chapter, we followed several methods.

1. Study Design

In Spring 2012, the web application was ready to be tested by users representing public health departments, laboratories, infection preventionists, and healthcare providers. Between March 14 and 21, 2012, we conducted usability testing with ten users, including (a) four public health epidemiologists from the UDOH, Washington State Department of Health (WADOH), Denver Public Health Department, and Spokane Regional Health District, (b) two reporting compliance officers from a national reference laboratory and a central laboratory for a multi-hospital healthcare enterprise, (c) two infection preventionists from a major healthcare enterprise in Utah, and (d) two physicians from two major healthcare enterprises in Utah. Of the ten users, four users had not previously participated in the usability test sessions described in Chapter 3. The four `new' users include (a) one public health epidemiologist, (b) one reporting compliance officer, (c) one infection preventionist, and (d) one physician.

At the beginning of each usability test session, one researcher (DR) informed the user regarding the goal of the test session. Then, the researcher specified a list of scenarios and associated tasks that the user was asked to conduct using the web application. The scenarios and associated tasks that we compiled were based on the type of user. For example, users representing healthcare providers were tasked to find the reporting specifications applicable to healthcare providers. Users representing laboratories and infection preventionists were tasked to identify the reporting specifications for both laboratories and hospitals. Users representing public health epidemiologists were tasked to query for the reporting specifications for laboratories, hospitals, and healthcare providers. The script used during the usability test sessions with users from public health, laboratories,

and infection preventionists can be found in Appendix E. As an example, we include the script used during the usability test sessions with the healthcare providers below.

Script for users representing healthcare provider

Public health reporting is mandatory for laboratories and clinical facilities. Currently, reporting specifications are published by public health departments on individual department websites. We are developing a web-based prototype public health reporting system that would include public health reporting specifications for laboratories, healthcare providers, and hospitals. The purpose of this session is to assure that we are developing a user-friendly application that meets the needs of the users.

We have identified three scenarios that we would like to test in this usability session. The three scenarios and the specific tasks associated with each scenario are below:

i. Scenario: You are a healthcare provider. You have been tasked with identifying the reporting specifications for all conditions reportable in multiple jurisdictions.

Tasks:

a) Identify the healthcare provider reporting specifications for conditions reportable in the following jurisdictions: Colorado, Utah, and Washington.

Questions:

a) What did you think of the content organization and display of the query screen while conducting the tasks for this scenario?
b) Does the information flow make sense to a healthcare provider?
c) The display for healthcare providers shows only the reporting time frame. Would you like any other data elements to be displayed in this view?

d) The display for healthcare providers displays the information based on the reportable condition and does not specify either the clinical finding or the laboratory finding. Do you agree with this display?

ii. Scenario: You are a healthcare provider. You have been tasked with identifying the reporting specifications for all conditions reportable in a particular jurisdiction.

Tasks:

a) Identify the healthcare provider reporting specifications for conditions reportable in either one of the jurisdictions: Colorado, Utah, and Washington.

Questions:

a) What did you think of the content organization and display of the query screen while conducting the tasks for this scenario?

b) Does the information flow make sense to a healthcare provider?

c) The display for healthcare providers shows the reporting time frame, the link to the form, and the preferred method of reporting. Would you like any other data elements to be displayed in this view?

d) You can obtain the reportable specifications for a specific jurisdiction from the view that displays all the conditions reportable in multiple jurisdictions by clicking on the specific jurisdiction. For example: Utah. Is this conveyed by the current display?

iii. Scenario: You are a healthcare provider. You want to identify the reporting specifications for Chlamydia trachomatis for either of the jurisdictions: Colorado, Utah, and Washington.

Tasks:

a) Identify the healthcare provider reporting specifications for Chlamydia trachomatis in either of the jurisdictions: Colorado, Utah, and Washington.

Questions:

a) What did you think of the content organization and display of the query screen while conducting the tasks for this scenario?
b) Does the information flow make sense to a healthcare provider?
c) The default display for healthcare providers shows the reporting action. The reporting criteria and references are displayed using progressive disclosure. Do you agree with this display?
d) You can obtain the reportable specifications for Chlamydia trachomatis infection for a specific jurisdiction from the view that displays all the conditions reportable in multiple jurisdictions by clicking on the associated reporting time frame. For example: 3 days. Is this conveyed by the current display?
e) You can also obtain the reportable specifications for Chlamydia trachomatis for a specific jurisdiction from the views that displays all the conditions reportable in that jurisdiction by clicking on the reportable condition. For example: Chlamydia trachomatis infection. Is this conveyed by the current display?

All the users conducted the tasks by accessing the application using the researcher's computer. Of the ten users, three users were not located in Utah. We used Go-To Meeting [10] to conduct the usability test sessions with these users. The remote users were given `mouse and keyboard' control of the researcher's computer, thus simulating an in-person usability test session. Of the seven in-person usability test sessions, three were conducted at the workplace of the user and four were conducted at the researcher's aca-

demic department. We used a usability technique called `think-aloud' [11, 12, 13, 14, 15] and therefore the user was asked to vocalize their thought-processes while conducting the tasks. While the user conducted the tasks, the researcher observed the user's interaction with the web application and took notes.

IRB exemption was obtained for this study from the University of Utah.

2. Evaluating the Usability of the User-Interface of the Web Application:

After each usability test session, the researcher used the Nielsen-Shneiderman heuristic evaluation method [11] to determine the heuristics violated by the web application while the user conducted the specified tasks. The researcher used the 14 heuristics proposed by Zhang et al [16] that were described in Table 2.1in Chapter 2. In brief, the 14 heuristics are: Consistency and standards [Consistency]; Visibility of system state [Visibility]; Match between system and real world [Match]; Minimalist; Minimize memory load [Memory]; Informative feedback [Feedback]; Flexibility and Efficiency [Flexibility]; Good error messages [Messages]; Prevent errors [Error]; Clear closure [Closure]; Reversible actions [Undo]; Use user's language [Language]; Users in control [Control]; Help and documentation [Document].

The severity of each heuristic violation was rated using a scale of 0 to 4 (0: not a usability problem, 1: cosmetic problem, need not be fixed unless extra time is available, 2: minor usability problem, fixing this should be given low priority, 3: major usability problem, fixing this should be given high priority, 4: usability catastrophe, imperative to fix).

3. Identification of Additional Requirements for Content and Representation of Public Health Reporting Specifications:

After the user completed the tasks associated with each scenario, the researcher interviewed the user to identify additional requirements for the content and representation of the public health reporting specifications. It has been found that an open-ended interview following a usability test session helps the researcher elicit more information from the user [17]. During the interview, the user sometimes conducted the relevant task again to illustrate to the researcher the modifications or additional requirements that he or she considered necessary.

Results

The results of the usability of the user-interface of the web application and the additional requirements identified are summarized below:

1. Evaluating the Usability of the User-Interface of the Web Application:

The heuristic evaluation of the web-based system for public health reporting specifications found that 10 of the 14 heuristics were violated while the users conducted the specified tasks. Some of the most frequently violated heuristics were the Visibility, Memory, Feedback, Document, and Flexibility heuristics. Most of the heuristic violations were considered minor (severity rating: 2) and major (severity rating: 3). None of the heuristics were rated as catastrophic.

Figure 4.1illustrates the usability problems identified with the display of the query screen. Figure 4.2 depicts the usability problems arising due to an absence of a legend. Figure 4.3 gives an example of a usability problem identified when the user tries to view multiple assets at a time. A description of all the violations identified is displayed in Table 4.1.

2. Identification of Additional Requirements for Content and Representation of Public Health reporting Specifications:

All the users reported that they would find this application useful provided it integrated with their existing workflow. The infection preventionists informed the researcher that they could use the `Multiple states all conditions' view to help them prioritize their reporting. For example, if they had to report chlamydia trachomatis infection cases to Utah and Colorado, they could look at the reporting time frame displayed in the `Multiple state all conditions' view and prioritize reporting the case to Utah since the reporting time frame in Utah is 3 days as opposed to 7 days in Colorado.

The post-usability session interview with the users helped us identify the following additional requirements:

i. All users want the title of the application to be changed from `Public Health Reporting Tool' to 'Public Health Reporting Requirements'. The current title misinformed the users into thinking that the application in its current form would help them transmit reports to public health entities.

ii. Public health epidemiologists want the word, `Major' to be removed from the `Major jurisdiction(s) of interest'.

iii. Public health epidemiologists want to change `Show reportable events by laboratory findings' to Show reportable events by organism' on the query screen.

iv. Public health epidemiologists want to change `Show reportable events by clinical findings' to `Show reportable events by clinical diagnosis' on the query screen.

v. Public health epidemiologists want to change 'Reportable event by organism' to `Reportable organism (Reportable event)' in the `Multiple state all conditions' view

and the One state all conditions view. The current title does not clearly specify what the information in the parentheses represents.

vi. Public health epidemiologists want to change `Jurisdiction' to `Reporting time frame by jurisdiction' in the `Multiple states all conditions' view. The current display does not specify explicitly that the information displayed is the reporting time frame.

vii. Users from the laboratories only want the reportable organism to be displayed. The current view displays the organism with the associated reportable event in parentheses.

viii. Public health epidemiologists want some indicator next to the name of the jurisdiction (e.g., Colorado) to indicate that users can click on it to view all the conditions reportable in that jurisdiction.

ix. Users from the clinical facilities want the phone icon to be displayed next to the reporting time frame for immediately reportable events in the `Multiple states all conditions' view.

x. Users want the `One state one condition' view to display all the methods of reporting (but highlight the preferred reporting method) by default. The current view only displays the preferred method of reporting.

xi. Users from the laboratories want the capability to download the reporting criteria logic to help update laboratory detection systems.

xii. Users from clinical facilities want the application to be integrated into the electronic health record to improve accessibility of the application and to support the automated creation and transmission of public health reports.

xiii. All users want to change `Test result' to `Reportable test results' in the reporting criteria. The information displayed under `Test result' is supposed to inform the user whether all test results are to be reported or only positive results. It is not the value of the laboratory test result. Similarly, the users want to change `Positive' to 'Positives only' to make it clear that the information displayed in that column is not the laboratory test result. The current display is illustrated in Figure 4.4.

xiv. Users from laboratories and clinical facilities recommended that the system incorporate a log-in mechanism that allows users to save their default selections instead of requiring them to re-enter the query every time.

xv. Users from the laboratories want the default view for the `One state one condition' to display both the reporting action and the specimen submission action at one time.

xvi. All users want the capability to see all the information in the `One state one condition' view simultaneously. The current display closes one asset when the user opens another asset, thus preventing the user from seeing the information from all assets at one time.

xvii. Public health epidemiologists and the representatives from the laboratories want the specimen submission action to also display the type of specimen, the volume, the required level of packaging, and the URL to the receiving public health laboratory.

Discussion

We evaluated the usability of the web application for public health reporting specifications and identified additional requirements to meet the needs of the users from laboratories, hospitals, healthcare providers, and public health departments.

The heuristic evaluation study identified specific problems that should be addressed before the system can be implemented in the real world. Previous usability tests did not involve the web-based interactive application but involved low-fidelity mock-ups of the displays. Therefore, it is to be expected that the usability evaluation with the interactive application would identify problems associated with the interaction between the user and the system. Thus, illustrating the importance of user testing during the system design and development.

A heuristic evaluation of three public health department websites was described in Chapter 2. That study showed that public health department websites violated six of the 14 heuristics used in the study. The heuristic evaluation conducted with the web application identified usability issues that were different from what we had identified with the Websites. This is to be expected because public health department Websites are not interactive and cannot be queried. Hence some of the heuristics that were violated by the web application did not apply to the public health department Websites. Some examples are the Undo and the Control heuristics. The Undo and Control heuristics were violated because the system did not save the user's selections on the query screen. Thus, the system did not allow the users to back-track or leave an unwanted state easily.

The heuristic evaluation study has limitations. The violations to heuristics were identified by one researcher based on the observations made by the researcher while the users were using the application. We recommend including at least two evaluators to assess heuristic violations after the system is enhanced.

We also identified additional requirements for the content and the representation of the reporting specifications displayed by the application. Some of the requirements

identified by the users can be supported by the present infrastructure. For example, the requirement to display the type of specimen and the level of packaging can be met by populating the relevant data elements in the XML body of the specimen submission action. The current model supports this additional information but the content was not authored and hence was not displayed. However, some of the requirements cannot be supported by the present application without considerable infrastructure development. For example, the system for public health reporting specifications needs to be integrated into the workflow of the users. We found that users from clinical settings want the application to integrate into the electronic health record to support the automated detection of reportable events, creation of the public health report, and electronic transmission to the public health department. However, the current system cannot support such a requirement. One possible method would be to use the infobutton standard in the XML header to enable access to the content from the electronic health record. Full integration would require the development of interfaces and a decision support engine to process the content designed in the knowledgebase.

During the evaluation process, we also identified some compatibility issues of the web application. The application runs only on the Mozilla Firefox web browser. It is not compatible with the Internet Explorer browser, which is widely used in one of the major healthcare enterprises in Utah. We have also not tested whether the application would work on operating systems other than Windows Vista and Windows XP. Similar to most other web applications, the display depends on the browser's resolution settings on the user's computer.

In conclusion, we used usability techniques such as think-aloud and heuristic evaluation to evaluate the usability of a web application for public health reporting specifications. We identified several usability problems that were both major and minor. To increase adoption, efforts should be made to integrate the application itself or the knowledge displayed in the application with information systems at the reporting facilities.

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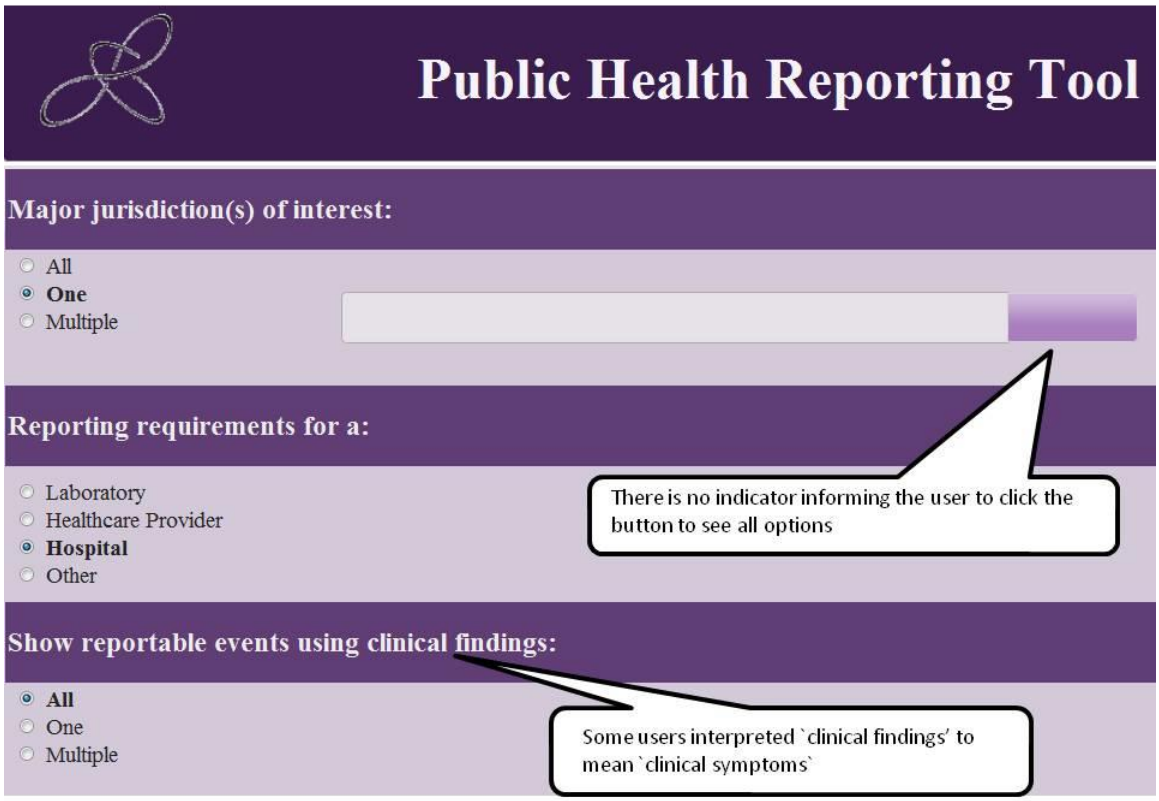
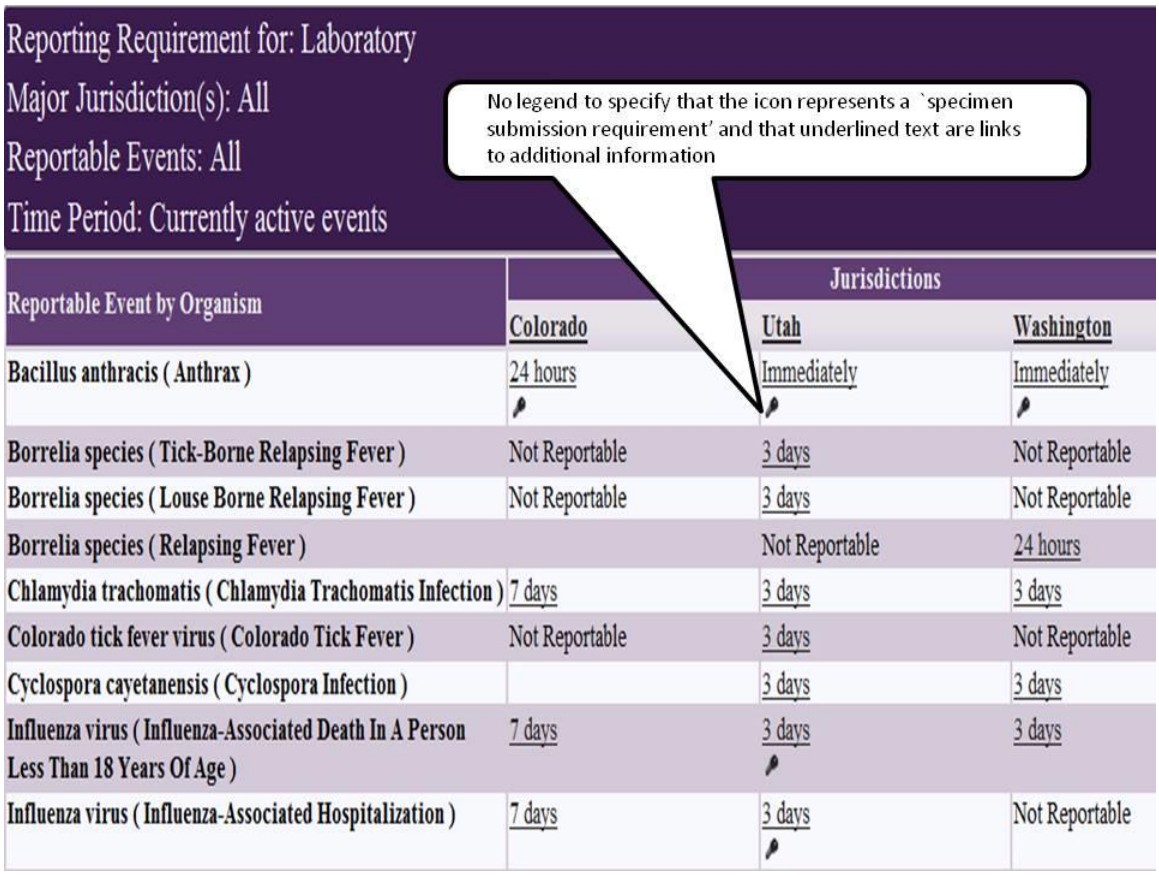


Figure 4.1: Usability problems identified with the current display of the query screen



Reportable Event by Organism	Jurisdictions		
	Colorado	Utah	Washington
Bacillus anthracis (Anthrax)	24 hours	Immediately	Immediately
Borrelia species (Tick-Borne Relapsing Fever)	Not Reportable	3 days	Not Reportable
Borrelia species (Louse Borne Relapsing Fever)	Not Reportable	3 days	Not Reportable
Borrelia species (Relapsing Fever)		Not Reportable	24 hours
Chlamydia trachomatis (Chlamydia Trachomatis Infection)	7 days	3 days	3 days
Colorado tick fever virus (Colorado Tick Fever)	Not Reportable	3 days	Not Reportable
Cyclospora cayetanensis (Cyclospora Infection)		3 days	3 days
Influenza virus (Influenza-Associated Death In A Person Less Than 18 Years Of Age)	7 days	3 days	3 days
Influenza virus (Influenza-Associated Hospitalization)	7 days	3 days	Not Reportable

Figure 4.2: Usability problems arising due to a lack of a legend

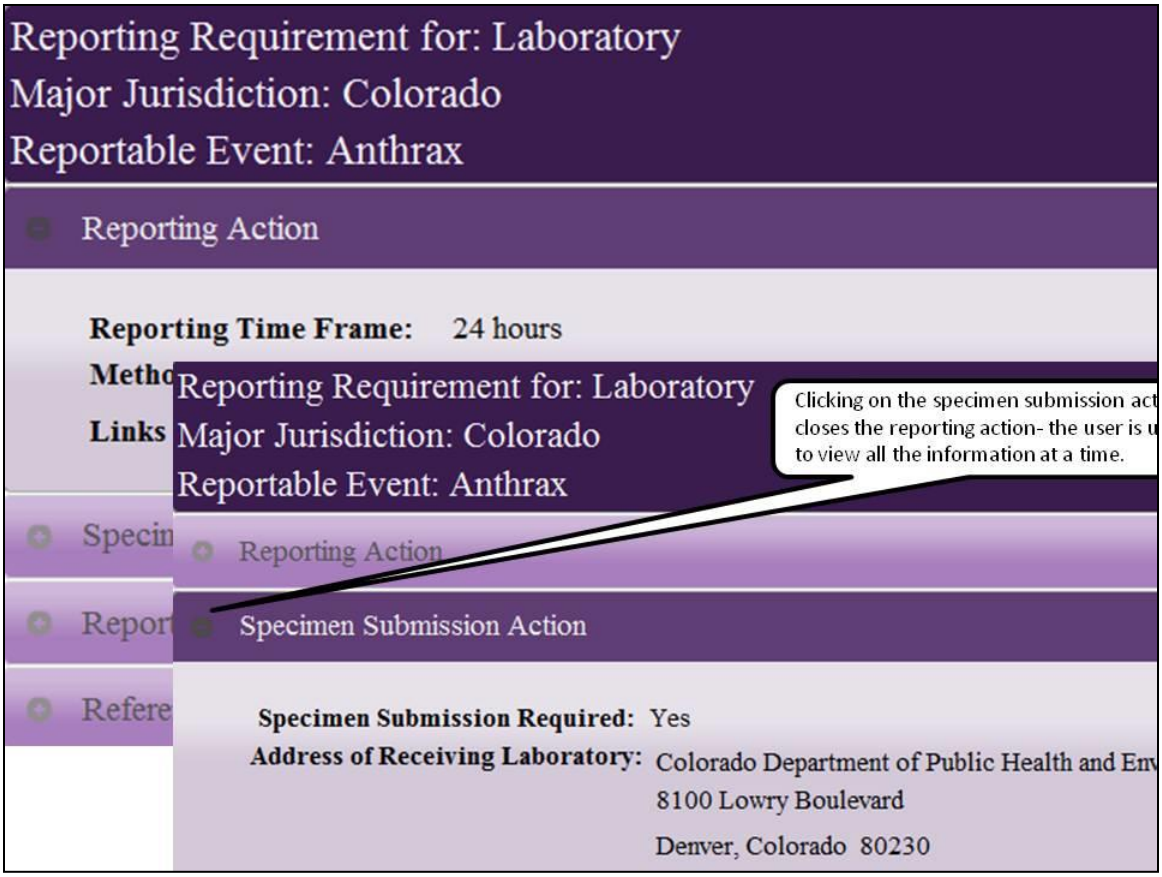


Figure 4.3: Usability problems identified when a user wants to view all the assets relating to reporting specifications at the same time

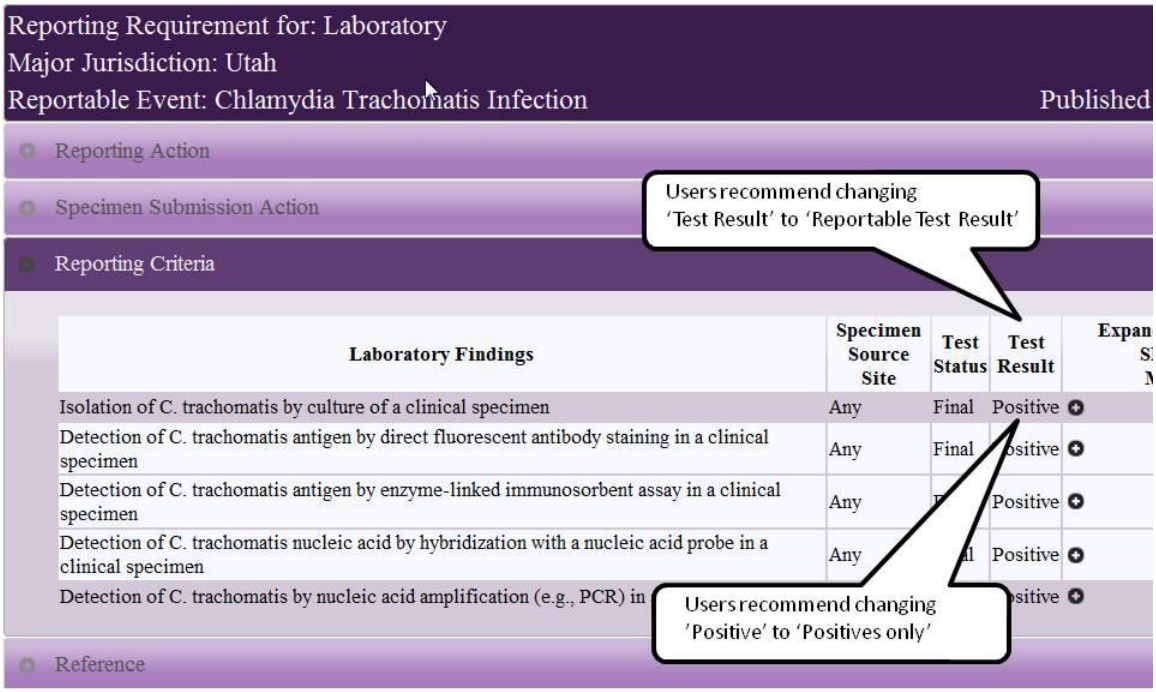


Figure 4.4: Modifications needed to the test results

Table 4.1: Summary of usability violations observed in the web application for public health reporting specifications

Actions Performed	Usability Problem Description	Heuristics Violated	Severity
Selecting multiple jurisdictions or reportable events from the query screen.	The users must either use the CTRL or the SHIFT key to make multiple selections but some users were not aware of this feature and were not able to make multiple selections.	Visibility Memory Feedback Document	3 3 2 3
Selecting one jurisdiction or one reportable event from the query screen.	The users must click on a specific button to obtain the drop-down list of all available options. When the user hovers over the button with the computer mouse, a 'Show all options' is displayed but this is not obvious to some users.	Visibility Memory Feedback Document	3 3 2 3
Selecting the reportable event using laboratory findings or clinical findings.	The users were unsure about the meaning of laboratory and clinical findings; some users thought that laboratory findings represented laboratory test results and clinical findings represented clinical symptoms.	Language	2
Specifying the required query on the query screen.	The users must use the computer mouse to specify their selections and not the computer keyboard; some users prefer using the keyboard.	Flexibility	2
Going back to the previous screen.	The application does not have a `Back' button on the display; the user is supposed to use the browser's back button to access the previous screen. But some users expected to see a `Back' button on the screen and were unsure how to go back to the previous screen.	Match Flexibility	1 1
Accessing a link that has already been visited.	The display for links that have been visited and have not been visited is the same. A visited link does not change color.	Consistency	1

Table 4.1 (Continued): Summary of usability violations observed in the web application for public health reporting specifications

Actions Performed	Usability Problem Description	Heuristics Violated	Severity
The user expands the Specimen submission action or the reporting criteria or the references assets in the One state one condition view.	Opening one asset of information automatically closes the previously opened asset; the user cannot view the information from all assets at the same time.	Flexibility	2
Identifying the other methods of reporting.	Only the preferred method of reporting is displayed. The user has to click on a plus icon to view the other methods of reporting, but this feature was not clear to some users.	Visibility Memory Feedback Document	3 3 3 3
Going back to the query screen to modify some selections.	The application does not save the selections entered by the user; going back to the query screen provides the default selections to the user and the user has to re-select the options again.	Flexibility Undo Control	2 2 2
Accessing the `One state all conditions' or the `One state one condition' from the `Multiple state all conditions' view.	The user has to click on the underlined text to obtain other views. This feature is not obvious to some users.	Visibility Memory	2 2
Severity scale (1:cosmetic, 2: minor, 3:major)			

CHAPTER 5

DEVELOPMENT OF AN ELECTRONIC PUBLIC HEALTH CASE REPORT USING HL7 V2.5 TO MEET PUBLIC HEALTH NEEDS[1]

Abstract

Clinicians are required to report selected conditions to public health authorities within a stipulated amount of time. The current reporting process is mostly paperbased and inefficient and may lead to delays in case investigation. As electronic medical records become more prevalent, electronic case reporting is becoming increasingly feasible. However, there is no existing standard for the electronic transmission of case reports from healthcare to public health entities. We identified the major requirements of electronic case reports and verified that the requirements support the work processes of the local health departments. We propose an extendable standards-based model to electronically transmit case information and associated laboratory information from healthcare to public health entities. The HL7 v2.5 message model is currently being implemented to transmit electronic case reports from Intermountain Healthcare to the Utah Department of Health.

[1] Reprinted with permission from Journal of the American Medical Informatics Association, 2010, 17(1), 34-41. Rajeev D, Staes CJ, Evans RS, Mottice S, Rolfs R, Samore MH, Whitney J, Kurzban R, Huff SM. Development of an Electronic Public Health Case Report using HL7 v2.5 to Meet Public Health Needs

Introduction

Surveillance of communicable and noncommunicable diseases is vital for their prevention and control. For this purpose, every state in the USA has a list of `reportable diseases' which specifies the conditions that are reportable in that state and the timeframe by which the conditions are to be reported [1]. When a reportable disease is identified, clinicians and laboratories are required to report the case to public health authorities. In most hospitals, the responsibility for reporting is delegated to an infection preventionist. The information included in a case report is used: (1) to track disease incidence and identify outbreaks; and (2) to allow public health officials to make informed decisions and implement appropriate control measures to prevent the spread of disease. Hence, the quality and timeliness of control measures depend on the quality and timeliness of the reports. Incomplete or delayed case reports can result in new occurrences of disease that could have been prevented.

The current process for public health case reporting in the USA is paper-based, often inefficient, and involves nonstandard case report forms that vary by state. In Utah, the case report forms vary by reporting source. For example, over the past 20 years, one healthcare organization included data fields that were added piecemeal over time as requested by public health, and without any review of the continuing utility of data fields. We found no published literature that describes a systematic assessment of the content of case reports to support public health workflow.

Electronic health records (EHRs) are becoming more prevalent and provide new opportunities for electronic case reporting [2]. Currently, there is no existing standard guideline for the electronic transmission of case reports from healthcare to public health

entities. Recently, there have been national efforts to define the data fields to be included in a case report [3] and to develop disease-specific implementation guides using the HL7 Clinical Document Architecture [4]. While these efforts have informed our research and our research has informed their work, there continues to be a need to develop standard guidelines for electronically reporting any reportable condition using currently implemented technologies. We identified the major requirements for electronic case reporting and propose an extendable standards-based model to electronically transmit case information from healthcare to public health entities.

Throughout this paper, the term `case report' will refer to a report sent from healthcare facilities to public health entities.

Background

The reporting process involves multiple steps including case detection, recognition that the case is reportable, extraction of relevant data, and transmission of case information to public health authorities. In general, the state health department is responsible for routing the data to the local jurisdiction where the patient resides, the local health department initiates case investigation and implementation of control measures, and finally, the state health department is responsible for analyzing and disseminating information to key stakeholders and public health partners. Thus, the timely delivery of complete case reports is a crucial step in the reporting process. The current reporting process is mostly paper-based, involving faxed or phoned reports. Manual processes may suffer from several disadvantages, including delays in reporting, missing faxes, incomplete information in a report, and errors in manual data entry [5, 6, 7].

Electronic systems that transmit laboratory data for reportable diseases to health departments have been implemented in a few states. Electronic laboratory reporting (ELR) has increased the volume (2.3 to 4.4 fold) and timeliness (3.8 to 7.9 days earlier) of reporting compared with the traditional faxed reports [8, 9, 10, 11]. In 2007, research in New York City showed that ELR was more timely and complete than paper-based reporting, but it created new problems in data quality, shifted work demands, and required additional skills for data monitoring [12]. While ELR has the potential to have a positive impact on disease reporting, it should not replace the clinician's responsibility to submit case reports to public health [13]. There are major disadvantages with ELR-based systems: only diseases diagnosed using laboratory tests are identified and ELR messages often do not include patient demographics, location, and clinical data that are important for public health surveillance and case management. These drawbacks indicate the need for electronic case reporting.

As the use of EHRs becomes more prevalent in the US, there are increasing opportunities for electronic case reporting. While an electronic case report may contain laboratory results similar to an ELR message, a case report also includes information about patient demographics, clinical findings, and other relevant data that can be extracted from the EHR. Systems that automate the transmission of a case report are being developed, but currently have limited scope [14]. In 2007, the American Health Information Community (AHIC) selected public health case reporting as a priority area. In 2008, the Office of the National Coordinator for Health Information Technology developed a use case for public health case reporting that focuses on information exchange between a provider's EHR, public health organizations, and laboratories [15]. There are national efforts to

standardize the process of case reporting from healthcare settings to local or state public health and from state public health to the Centers for Disease Control and Prevention (CDC). There are guidelines published by the CDC to electronically transmit nationally notifiable conditions from public health entities to the CDC [16] and there is a standard for ELR [17]. However, there is no existing standard for the electronic transmission of a case report from healthcare facilities to public health entities (Figure 5.1).

In the USA, each state requires that a specific set of diseases be reported to public health authorities by a clinician who diagnoses the condition, regardless of laboratory confirmation. In Utah, there are currently 74 diseases on the list of "reportable diseases". Since 1985, LDS Hospital has been using automated case detection logic, primarily based on laboratory results, to identify reportable diseases [18, 19]. The case report that is generated includes clinical data extracted from the EHR and supporting laboratory information. The system is currently implemented at 21 Intermountain Healthcare hospitals. Case reports are emailed daily to infection preventionists in each facility. Until recently, the local and state health departments in Utah did not have an information system to receive the case reports electronically. Therefore, the current reporting process at Intermountain Healthcare hospitals involves an infection preventionist printing and faxing the reports to the local health departments or the Utah Department of Health (UDOH).

In Utah, a new law was enacted in 2008 that gives the UDOH the authority to require that standards be used for electronic health information exchange [20]. To meet this new requirement and improve the efficiency and quality of case reporting, our goal was to develop a standards-based model for sending an electronic case report from a healthcare facility to a public health entity. There are many steps required to realize the

goal of improving the reporting process for reportable diseases. A major step is ascertaining the requirements of a case report from the perspective of local and state public health departments. Therefore, the objectives of the research described in this paper were to (1) describe public health workflow and identify requirements for the case report to support workflow, (2) specify the content for an electronic case report that meets public health needs and is feasible to extract from the EHR, and (3) model the information for a case report and identify standards for concepts and value sets.

Methods

To meet the objectives outlined above, we conducted the following methods:

1. Workflow Analysis:

To describe public health workflow and identify requirements for the case report to support workflow, it is important to understand the tasks, data systems, and personnel involved with processing case reports at a health department. Local health departments receive reports of reportable diseases from clinics, laboratories, hospitals, state health departments, and patients. The follow-up of a report at the local health department is a complicated process.

In early 2007 and 2008, we conducted preliminary analyses of the work processes associated with managing a case report. In December 2008, a formal workflow analysis using cognitive task analysis techniques was performed to verify the processes and data needed to support the workflow. We observed the tasks performed by various personnel at Salt Lake Valley Health Department (SLVHD), the largest local health department in Utah. These observations along with several interviews of the nurses and case investiga-

tors helped document the workflow associated with processing a case report. The workflow was validated with case managers and surveillance practitioners at the UDOH and Davis County Health Department, a local health department in Utah.

2. Content Analysis:

To specify the content for an electronic case report that meets public health needs and can be extracted from the EHR, we used several methods and data sources.

First, we examined the content of the current case reports generated from the Intermountain Healthcare EHR that are faxed to public health. The content of the faxed case report represented the data that can be extracted from the EHR and the information considered essential over the past 20 years that the report has been in use.

Second, in late 2007, we reviewed the set of data fields that were identified for inclusion in a Confidential Morbidity Report formulated by the Case Report Standardization Workgroup led by the CDC and the Council of State and Territorial Epidemiologists (CSTE). One of the goals of the Workgroup was to identify a minimum set of common data elements for electronic case reporting from healthcare providers to public health. While we were in the process of ascertaining the content of an electronic case report, the CDC/CSTE workgroup was also in the process of identifying the set of data elements required for case reporting using input from public health epidemiologists from at least seven states.

Third, we gathered data requirements from public health practitioners from the UDOH and two local health departments (SLVHD and Davis County Health Department). The health department personnel were practitioners involved with both case investigation (and management) and surveillance because these two activities involve dif-

ferent workflow and data needs, although they are both dependent on case reporting. We met between July 2007 and August 2008 to review the data fields to be included in the report.

3. Modeling and Value Set Analysis:

To model the information for a case report and identify standards for concepts and value sets, we investigated existing and evolving standards.

First, we reviewed the guideline for electronic transmission of nationally notifiable conditions from public health entities to CDC using HL7 v2.5 [16] and the implementation guide for electronic transmission of electronic laboratory reports associated with notifiable conditions [17]. We evaluated the strengths, limitations, and heuristics needed to model the information included in a case report.

Second, we reviewed existing standards for their use in the message. In particular, we reviewed Logical Observation Identifiers Names and Codes (LOINC), Systematized Nomenclature of Medicine- Clinical Terms (SNOMED CT), and other codes and value sets in Public Health Information Network Vocabulary Access and Distribution System (PHIN VADS). For example, we reviewed the National Notifiable Disease Surveillance System (NNDSS) codes in PHIN-VADS [21] and the "Dwyer tables" [22] used for laboratory case detection particularly for ELR. This analysis was conducted by a team of collaborators with experience in public health epidemiology, microbiology, and biomedical informatics. We used the CliniClue Browser [23] to map Utah's 74 reportable conditions [24] to SNOMED CT (International version 0807).

Results

The results of the workflow, content, and modeling and value set analyses are summarized below:

1. Workflow Analysis:

The workflow associated with receiving and investigation of case reports at local health departments can be divided into seven processes.

i. Triage: The triage task begins with the initial receipt of a report. The main goals of triage is to identify the requirement of additional information before the report can be further processed and determine whether the case belongs to the jurisdiction to which it has been reported. Cases which are reported to the appropriate jurisdiction proceed to the data input phase. Otherwise, cases are forwarded to the state health department to be re-routed to the appropriate jurisdiction.

ii. Initial Data Entry: If the case was previously reported, the surveillance database is updated with any new information. If the case is new, the data is entered in the surveillance database and the case is assigned a unique identifier.

iii. Assignment: The Assignment process is a manual process and involves the identification of the responsible investigation team for each case.

iv. Investigation: The investigation process involves contact tracing, re-contact with the healthcare system to gather more information, and implementation of control measures.

v. Review: This process involves the review of the case by the Nurse Supervisor during or after the case has been investigated by the nurse.

vi. Archive Case Information: After the investigation is completed and reviewed, the data pertaining to the case is stored in the long term archive which may be electronic or paper-based.

vii. Forward closed cases for state surveillance: All the case reports and relevant documents gathered during the case investigation are sent to the state health department after the case investigation is completed, or during an investigation for selected diseases of acute public health concern.

For an electronic case report to have a direct and positive impact on these work processes, we identified the following requirements:

i. Triage process: (a) Include enough information to allow the correct routing to the appropriate jurisdiction. Information regarding the patient address and the patient telephone number is needed to identify the appropriate jurisdiction. (b) Provide the identification of the primary contact person at the reporting facility so the public health official does not waste time seeking who to contact when additional information is required. (c) Include relevant data needed to assess urgency for case triage. The name of the reportable condition, the relevant laboratory results, and the hospitalization status are the minimum required information for case triage.

ii. Data Entry process: (a) Include the required information to link with any associated laboratory report that may arrive separately from the laboratory. The unique specimen accession number will enable automated linkage and reduce effort and time required to manually review and link records. (b) Provide enough information to link the report with existing reports for the same patient and the same reportable condi-

tion. Unique patient identifiers from the reporting facility, the test status, and the unique specimen accession number can be used for the linkage.

iii. Assignment: Include the name of the reportable condition to enable the automated assignment of cases to nurses.

iv. Investigation: (a) Include additional laboratory results to support the information reported, establish whether the case definition is met, and guide treatment, patient education, and control measures. For selected diseases (particularly hepatitis), the investigator must gather additional laboratory information to meet the above requirements. For this purpose, we recommend reporting all results in a laboratory order with the laboratory test that triggered the event. The transmission of all the laboratory results of the ordered panel will obviate the need for the investigator to manually gather this information and simplifies the selection of additional results to extract from the EHR. (b) Include information about medications ordered or administered so the public health investigator has more information to assess the implementation of appropriate control measures. For example, a nurse investigating a case of a child reported with pertussis will need to know that he has received the appropriate antibiotics and may return to school. In addition, this information will help the nurse investigator prioritize cases that need to be investigated.

2. Content Analysis:

We identified six categories of information that should be included in a case report. The categories and the specific content are described in Appendix F. Although the content requested by different stakeholders was similar, we found a few differences in the opinions of local and state surveillance practitioners and case managers, and between

Utah and national (CDC/CSTE) stakeholders. For example, state public health officials did not want to receive the date/time that a specimen was received in the laboratory; however, this information was requested by local public health officials. Similarly, Utah public health authorities requested the unique patient identifier from the medical record system, but this information was not requested by the stakeholders in the CDC/CSTE workgroup tasked with identifying elements for a confidential morbidity report. Finally, we identified data elements that were currently being included in the case report based on past requests for information, but were no longer needed by public health officials (e.g., patient room number, if hospitalized). Thus, it was important to involve all the relevant stakeholders in the process of identifying the content of a case report because they had different information needs based on the tasks they performed.

3. Modeling and Value Set Analysis:

We used HL7 version 2.5 [25] to transmit case reports from healthcare to public health entities because this was the latest version in use at the time this project was initiated. This version was acceptable to the Information Technology team at UDOH who were required to develop the interface to receive the reports. We recommend that the following segments be included in the message structure of an electronic case report: Message Header Segment (MSH), Patient Identification (PID), Patient Visit (PV1), Observation Request (OBR), and Observation Result (OBX). A detailed description of the required data elements in a case report with their positions in the HL7 v2.5 message is given in Table 1a. This mapping was done using the HL7 v2.5 messaging standard protocol [26] by a team of investigators with experience in developing HL7 interfaces and biomedical informatics.

We adopted elements from the guideline for the electronic transmission of nationally notifiable conditions [16]. This guideline addresses the transmission of data from state public health entities to CDC and does not include patient identifiers such as patient family name, patient telephone number, reporting contact, etc. It also does not include the patient healthcare system encounter (visit) information and hence does not use the PV1 segment (which we recommend). However, the guideline for national reporting advocates the use of multiple OBR segments to transmit various categories of information. We adopted the Notification Type Identifier (NOTF) and the Associated Laboratory information Identifier (LABRPT) segments used in the national guideline, and hence the message structure we propose includes two OBR segments. Figure 5.2 illustrates a skeleton of the message structure.

The first OBR segment (defined as "NOTF" in OBR.4) and its associated OBX segments are used to transmit clinical and other information about the case that is not already included in the HL7 v2.5 MSH, PID, PV1, and the new "LABRPT" OBR segment. HL7 recommends transmitting such unspecified observations in OBX.3 using LOINC and the values in OBX.5. While mapping observations to LOINC, we found that certain observations, such as reporting contact's name and phone number do not currently exist in LOINC. We have requested new LOINC codes for these observations. In addition, we found that selected relevant LOINC concepts (e.g., date of diagnosis) were specific to cancer. We recommend that LOINC make selected concepts usable across disease categories and also include LOINC codes for concepts relevant to reportable condition reporting.

The second OBR segment (defined as “LABRPT” in OBR.4) and its associated OBX segments are used to transmit laboratory information. This segment mirrors the structure of laboratory information sent in ELR, including the use of LOINC codes in OBX.3 for laboratory test names, and the use of SNOMED CT codes in OBX.5 for test results when appropriate. We include the specimen accession number in the “LABRPT” OBR segment to enable linkage of the case report to the related ELRs arriving separately from the laboratory. The structure for OBR segments in the proposed message structure are shown in Figure 5.3.

To establish a standard value set for the ‘name of the reportable condition’, we reviewed several code sets and identified their strengths and limitations for use for the value set of reportable conditions. Some of the important features of an appropriate code for the ‘name of reportable condition’ in a case report are: (1) the concept should be unique and (2) the concept should represent a reportable condition by meeting the case definition, and (3) the concept must represent clinical diagnoses expected in a case report. The requirements for controlled medical vocabularies have been addressed in recent years [27].

We assessed the NNDSS codes in PHIN-VADS [21], we found that the codes represent the case definitions for conditions tallied for state-based surveillance and for transmission to the CDC, but not the clinical diagnoses expected in a clinical record. In addition, the NNDSS codes represent nationally notifiable conditions and do not currently include conditions that are not nationally reportable. For example, it does not include ‘influenza-associated hospitalizations’ which are reportable in Utah. When we assessed the “Dwyer tables”, we found a table of LOINC to NNDSS mappings used for laboratory

case detection. The "Dwyer tables" map a single NNDSS condition to multiple LOINC concepts that represent the various laboratory tests that may be used. The NNDSS codes have the problems already described, and the LOINC mappings only represent single laboratory tests, and thus are not useful for representing conditions based on clinical findings or a series of laboratory tests. The features of the "Dwyer tables" do not meet the requirement that the electronic case report include one unique code for each reportable condition. Hence, we concluded that concepts from the current "Dwyer tables" would not be appropriate for the value set of reportable conditions in the electronic case report.

Next, we assessed SNOMED CT (International version 0807) for its efficacy in standardizing the 'name of the reportable condition'. An appropriate code for a single reportable condition is defined as one where the concept and its children reflect the case definition for the reportable condition. We used CliniClue Browser [23] to identify SNOMED CT codes for Utah's 74 reportable conditions (available in Appendix G). SNOMED CT is useful because it represents clinical diagnoses and we were able to identify appropriate codes for 60 (81%) of the 74 reportable conditions in Utah. However, we found the following issues while mapping the remaining 14 reportable conditions. First, some of the existing concepts do not meet the case definition and do not represent reportable conditions because non-human conditions are included as children in the hierarchy. For example, the current code for Campylobacteriosis includes "Porcine intestinal adenomatosis", an animal disorder. Thus we recommend that there be SNOMED CT codes and hierarchy specific for human disorders. Second, there are no codes for some reportable conditions (e.g., Hepatitis F). We recommend that new codes for the missing conditions be created. Third, certain reportable conditions (e.g. Typhoid, Botulism) are repre-

sented by multiple SNOMED CT codes. For a case report to be useful for public health case management and surveillance, it needs to include a single code per reportable condition. The reportable condition for Typhoid includes both typhoid infection and typhoid carriers because they require similar public health response and follow-up. Currently, there are two separate codes for typhoid infection and carrier. We recommend that there be a new parent code to represent either infection or a carrier (e.g. Typhoid infection or carrier) and that the existing infection and carrier codes be included as its children. Similarly, the reportable condition for botulism includes two codes: one code is currently under the parent "clostridial infection", and the second code is currently under the parent "poisoning". We recommend that SNOMED create a new code for Botulism that includes these existing codes as children.

In summary, after a review of the above potential code sets, we determined that the use of SNOMED CT would be the most appropriate value set to transmit the 'name of the reportable condition' in OBR.31 of the "NOTF" segment. We have submitted our recommendations to SNOMED CT to improve the utility of the codes as a value set for reportable conditions in a case report.

Discussion

Increasing use of EHRs provides an opportunity to improve and automate case reporting, a process that is currently paper-based, inefficient, and often not complete and timely [8-11]**.** Our research addressed the gap in standardized guidance for the electronic transmission of case reports from healthcare to public health entities. Through stakeholder input and assessment and verification of public health workflow, we identified major requirements for electronic case reporting and propose an extendable message model us-

ing HL7 version 2.5, LOINC, and SNOMED CT codes. We specified the content for an electronic case report that meets public health needs and is feasible to extract from an EHR. The data requirements address: (1) the initial data needed by public health for the purpose of case investigations and implementation of control measures and (2) the addition of unique identifiers for the patient and triggering laboratory reports to support automated workflow. These findings are new and go beyond the information typically requested by state public health officials. We have developed an implementation guide for case reporting [28] using HL7 v2.5 that can be adopted by other healthcare and public health entities that want to electronically transmit public health case reports.

The HL7 version 2.5 implementation guide we developed has several strengths. First, it supports electronic information exchange and the automatic population of the surveillance database without the need for manual data entry. In contrast, the paper-based reporting process may involve reporting delays, missing faxes, incomplete information in a report, and errors in manual data entry [5-7]. Second, HL7 version 2 interfaces are widely used in healthcare and public health agencies. Therefore, there are existing technical and human resources available to implement a version 2.5 message guide. Third, the implementation guide we developed can be used for any current or future reportable condition and is not disease specific. The name of the reportable condition included in the message should be transmitted using SNOMED CT, but the message can also handle human readable local codes. In contrast, the implementation guides developed using HL7 version 3 Clinical Document Architecture (CDA) are disease specific [4] and do not currently handle reporting of a previously unspecified condition. Moreover, version 3 interfaces are more complex and not routinely implemented in public health and healthcare

settings in the United States. Fourth, the version 2.5 message model we propose can be implemented today and can be modified to include a CDA payload in an OBX segment if reporting facilities have the capability to send CDA-based reports. Fifth, the message guide fulfills the requirements of a new state law for standardized health information exchange [20]. Utah health Information Network (UHIN), a Utah-based Standards Development Organization, is reviewing the implementation guide for adoption by providers reporting to public health in Utah. The review and adoption process will include input from all UHIN member organizations including stakeholders from multiple healthcare organizations. Therefore, the message guide will be enhanced as needed and represent a practical solution that can be implemented today.

The research findings and the HL7 version 2.5 implementation guide we developed have limitations. First, the HL7 messaging standard is not simple to implement and maintain. However, it is the most widely used medical messaging standard in the United States and several other countries. In addition, HIPAA mandates the use of HL7 v2.2 or later versions to exchange medical data [29]. Second, the workflow observations were conducted in only one local health department. However, we validated the workflow findings with the personnel at a second local health department. Third, the content analysis we performed involved personnel from two local and one state health departments in Utah. While this may appear to limit generalizability of the results, we compared our findings with the content defined by the CDC/CSTE workgroup for a confidential morbidity report. We identified the same data fields with the exception of a few additional data fields (e.g., unique patient identifier). Fourth, the HL7 message structure we developed does not use the most current version today (May 14, 2009). However, standards

continually evolve and it is always necessary to select a reasonable version and at the beginning of the project version 2.5 was the latest version available. Fifth, the HL7 v2.5 messaging standard is based on an implicit information model not an explicit one. Also, v2.5 does not specify the terminology to be used in specific messages, which leads to multiple ways to implement the same message. V2.5 is also based on a "vertical bar" or pipe-delimited format which is not industry standard and does not integrate well with XML tools and the internet. Sixth, we do not use all currently available HL7 version 2.5 segments. For example, previous admission and discharge dates are being sent as OBX segments rather than using PV2.14 and PV2.26 respectively. For the next phase of the project, we will include the PV2 segment in the message structure to transmit information about previous admission and discharge date. Seventh, the use of the implementation guide requires that the healthcare facility and the public health entity have the infrastructure to send and receive HL7 messages. Finally, the content of the case report is not as comprehensive as that proposed for the development of CDA-based case reports, but the implementation will be sooner and does not prohibit the co-development of CDA-based implementation guides. Similarly, the current content of the case report model we developed does not include all the fields included in the proposed position statements for each individual disease designed for national surveillance [30]. However, the model can be extended to include other observations and represents the key information requested by public health that is currently capable of being extracted from an EHR.

Current status of implementation

Pilot testing of the implementation guide is being conducted between Intermountain Healthcare and the Utah Department of Health. The case reports are sent via Inter-

mountain Healthcare's secure interface eGate and the UDOH has developed the required infrastructure to receive the reports. Between December 2008 and April 2009, the interfaces were under development and testing. The cost to develop the format is estimated to be $5000 and the cost to build the parser is around $16000. However, this is just the cost to program, debug, and test the case reporting HL7 messages. The parser that was developed relied on a previously developed parser engine at a much higher cost.

By May 14, 2009, over 900 unique cases (daily average: 15 case reports) have been sent from two Intermountain Healthcare hospitals to the UDOH. Unit testing is currently underway to ensure that the data fields are being sent and received correctly in the HL7 v2.5 messages. To validate the messages sent from Intermountain Healthcare to Utah Department of Health (UDOH), we evaluate the content and format of the messages by comparing the data at Intermountain Healthcare prior to HL7 message translation with the HL7 message data received at UDOH. We conduct this QA process every three months for a week. Our findings are shared with IT teams at Intermountain Healthcare and UDOH and after the corrected messages are put in production, we repeat the QA test.

We will also evaluate the timeliness and completeness of the electronic system compared to the current paper-based system. The current manual reporting process will continue until the evaluation is completed and electronic case reporting has become an integral part of the statewide electronic surveillance system and public health workflow. The infrastructure to integrate the electronic case reports with the new statewide electronic public health surveillance system (UT-NEDSS) and use the data for real-time public health surveillance is underway. We will evaluate the impact of the electronic transmission of case reports on the workflow at the local and state health departments.

Conclusion

We have identified the major requirements for an electronic case report transmitted from healthcare to public health entities. We have also developed an extendable standards-based model using HL7 v2.5 that can be adopted by other healthcare facilities wanting to transmit case information and associated laboratory information to public health. It is expected that the use of this model will have a positive impact on public health surveillance in Utah.

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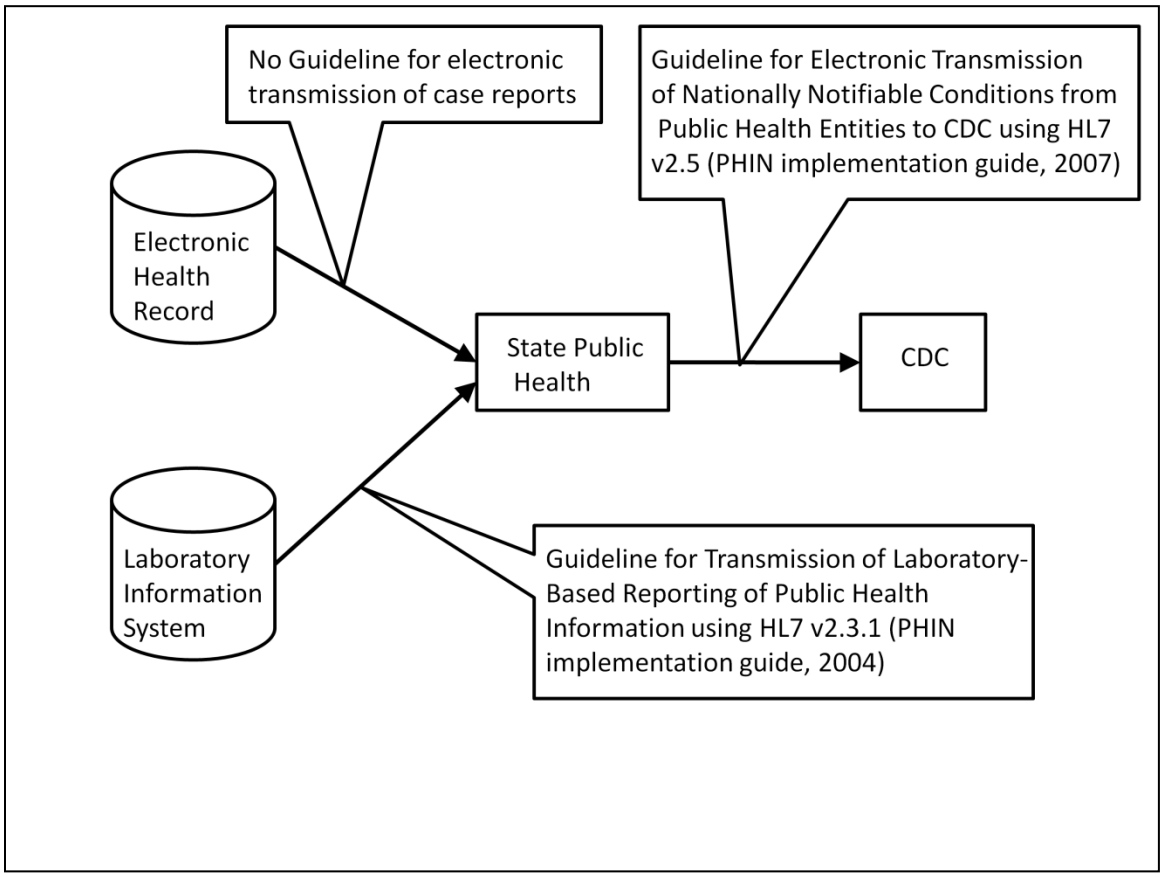

Figure 5.1: Description of existing implementation guides to support reporting to public health authorities

Message Header (MSH) < Reporting Facility, reporting system, date/time of report, etc.>
Patient Identification (PID) < Patient Identifiers, demographics, etc.>
Patient Visit (PV1) < Encounter number, hospitalization status, admission date, hospital service, etc.>
Observation Request (OBR) “NOTF” < Name of reportable condition>
Observation result (OBX) < Clinical information, admission diagnosis>
Observation result (OBX) < more clinical information>
Observation Request (OBR) “LABRPT” < Identifiers for linkage with ELR and specimen information – laboratory accession number, specimen collection date, test status, and specimen source>
Observation Result (OBX) < Other laboratory test names and results>
Observation Result (OBX) < Laboratory test name and results>

Figure 5.2: Key concepts in the proposed message structure.

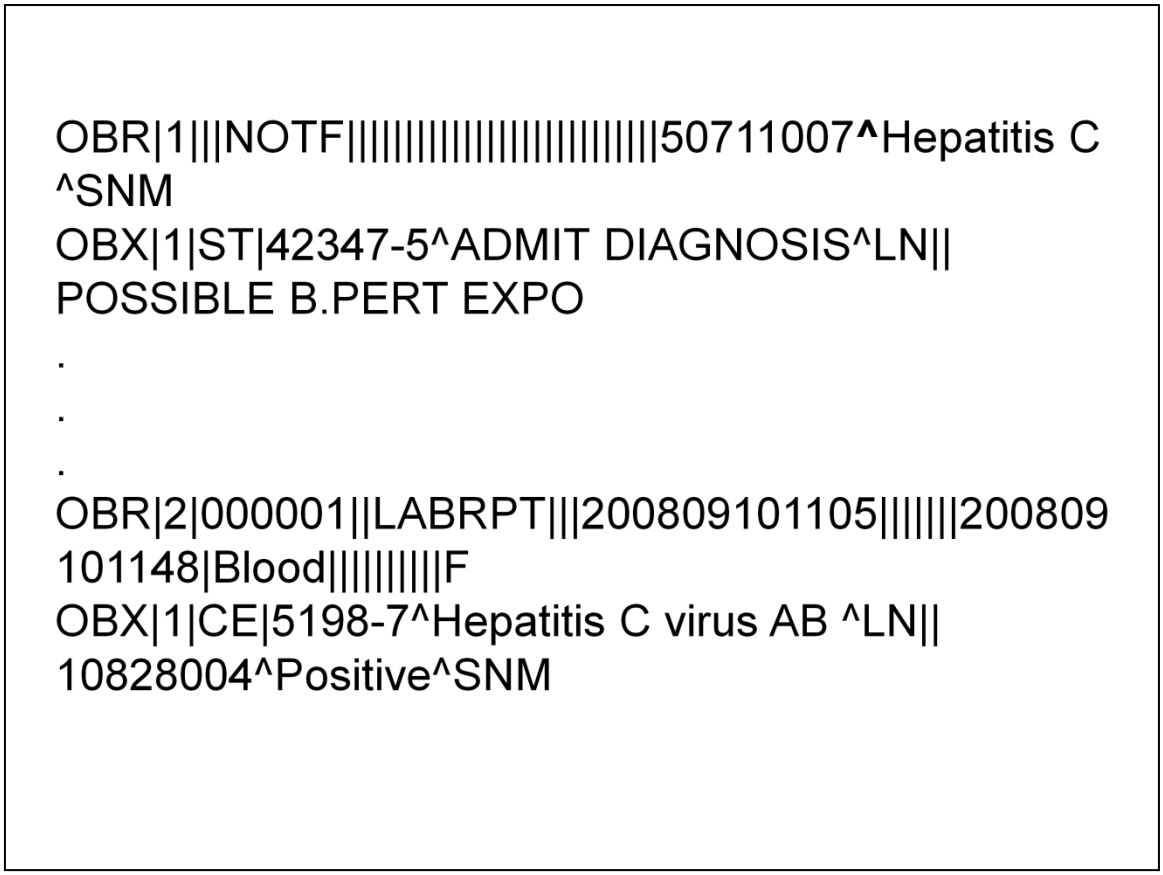

Figure 5.3: Details of the structure for observation request (OBR) segments in the proposed structure.

CHAPTER 6

EVALUATION OF HL7 V2.5.1 ELECTRONIC CASE REPORTS TRANSMITTED FROM A HEALTHCARE ENTERPRISE TO PUBLIC HEALTH[2]

Abstract

Public health surveillance is necessary to prevent and control communicable and non-communicable diseases. An electronic reporting system using HL7 v2.5.1 was implemented between Intermountain Healthcare and the Utah Department of Health. We conducted prospective and retrospective studies to evaluate the timeliness, completeness of content information, and completeness of the electronic reporting process, and compared these metrics against other reporting entities. The electronic reporting system was more timely than other clinical reporting facilities and included more complete information in initial case reports. During a four month period, the electronic reporting system captured 8% of the cases not reported by the paper-based reporting system but missed 5% of the cases reported by the paper-based reporting system. We believe it would be more efficient for Infection Preventionists at hospitals to use their resources to detect cases not

[2] Reprinted with permission from American Medical Informatics Association Annual Symposium Proceedings, 2011, 1144-1152. Rajeev D, Staes C, Evans RS, Price A, Hill M, Mottice S, Risk I, Rolfs R. Evaluation of HL7 v2.5.1 electronic case reports transmitted from a healthcare enterprise to public health.

captured by the electronic reporting system instead of manually re-reporting cases already transmitted to public health electronically.

Introduction

Public health surveillance is necessary for the prevention and control of communicable and noncommunicable diseases. To aid in the surveillance process, all states in the US publish a list of `reportable diseases'. These lists function as a communication between public health entities and reporting facilities regarding conditions reportable in that state. When a reportable condition is identified, healthcare facilities and laboratories are required to report the case to public health authorities [1]. For most diseases, public health officials utilize these reports to investigate the cases and implement appropriate control measures to prevent their spread. Hence, the quality and timeliness of the reports may impact the quality and timeliness of the implementation of control measures. Delayed or incomplete reports may contribute to new occurrences of disease that could have been prevented. Until recently, the reporting process in most states was paper-based and included problems due to reporting delays, missing reports, absence of relevant information needed for investigation, and errors in manual data entry [2, 3].

Several states have implemented electronic reporting from laboratories to public health authorities. A 2009 survey of laboratories found that 22 states were receiving electronic reports from laboratories for more than half of the diseases reportable in that state [4]. Electronic Laboratory Reporting (ELR) has been shown to improve the completeness of the reporting process and also result in more timely reports when compared with the paper-based reporting system [5, 6, 7, 8]. But, it has also been shown that ELR may have data quality problems and require additional skills for data monitoring [9]. Alt-

hough, ELR has several advantages over the paper-based reporting process, it should not supplant the case reports sent by clinicians and hospitals to public health [10] because an ELR: (a) can be sent for only those diseases that can be diagnosed using laboratory tests and (b) often does not include clinical data that are important for public health surveillance and case investigation. These drawbacks of ELR suggest the need for electronic case reporting. We define electronic case reporting as reporting from clinicians and hospitals to public health authorities. However, reporting from healthcare facilities is still predominantly paper-based. There are systems being developed to transmit case reports to public health authorities in the US but they are limited to certain diseases [11].

To improve the disease reporting and surveillance processes in Utah, the Utah Department of Health (UDOH) is collaborating with Intermountain Healthcare (Intermountain) to electronically transmit case reports from Intermountain facilities to the UDOH using HL7 v2.5.1, SNOMED CT, and LOINC codes [12. Since 1985, LDS Hospital (an Intermountain facility) has been identifying diseases reportable in Utah using automated case detection logic. The logic is primarily based on laboratory results [13, 14] and the generated case report includes clinical data and supporting laboratory information extracted from the electronic health record (EHR). At present, the system is implemented at 22 Intermountain Healthcare hospitals; the current process involves the reports being emailed daily at noon to the Infection Preventionists (IPs) at each Intermountain facility. The IP then prints and faxes the report to the local health departments or the state health department (UDOH). Currently, HL7 v2.5.1 messages are being simultaneously sent from two Intermountain facilities to the UDOH but automated integration of the electronic case reports with the state-wide surveillance system, UT-NEDSS, is under develop-

ment. Prior to integration, we are conducting several evaluation studies. In this paper, we will describe the results of analyses conducted during a prospective and a retrospective study period.

The main objective of the analyses were to evaluate the HL7 v2.5.1 electronic case reporting system by comparing the timeliness, completeness of information content in the initial report, and the completeness of the reporting process with current paper-based processes.

Methods

Data Sources

To accomplish the objectives of the study, we collected data from four different sources: (a) direct observations documenting reports received at Salt Lake Valley Health Department (SLVHD), the largest local health department in Utah, (b) UT-NEDSS, (c) HL7 v2.5.1 reports extracted from Intermountain prior to transmission, and (d) HL7 v2.5.1 reports received at the UDOH.

Linkage and Data Analysis

Linkage of reports from the four sources was done using unique identifiers, patient name, date of birth, and disease. Strawberry Perl 5.10.1.3 was used to parse the HL7 v2.5.1 reports extracted from Intermountain and the UDOH. All analyses were performed using SAS 9.2 (SAS Institute, Cary, NC).

Categories of Reporting Sources

The HL7 electronic case reports were sent from two Intermountain facilities- Intermountain Medical Center (IMC) and LDS hospital. As mentioned previously, reports from these two facilities are also sent by the IPs to public health using the paper-based system. We classified all the reports used in the study to be sent from six different types of reporting sources (Figure 6.1). We defined Intermountain IMC and LDS hospital as two sources of reporting: (a) the HL7 electronic reporting process and (b) the paper reporting process.

We shall refer to the HL7 electronic reports from Intermountain facilities- IMC and LDS hospitals as `HL7 IM-LD', paper reports from: IMC and LDS hospitals as `Paper IM-LD', other clinical Intermountain facilities as `Intermountain-other (clinical)', other clinical facilities as `Other (clinical)', Intermountain laboratories as `Intermountain (Labs)', and other laboratories as `Other (Labs)'.

Metrics

To evaluate the HL7 v2.5.1 electronic case reporting system, we used the following metrics:

Timeliness

Timeliness was assessed by calculating the interval between the specimen collection date and the date the report was first received at a public health department. The data extracted from UT-NEDSS had multiple specimen collection dates. Multiple collection dates may occur due to the following reasons. First, previous laboratory test information and corresponding dates are collected during the case investigation and entered in UT-

NEDSS. Second, subsequent laboratory test information are also added to the same record in UT-NEDSS when reported to SLVHD. Some of the test results corresponding to these collection dates may not be reportable (e.g., a chest X-ray for a TB case was performed outside the US). We consulted with three nurse managers at SLVHD to identify the appropriate date to use. We excluded cases that: (a) did not have a specimen collection date, (b) were updates to previously reported cases during the study period, (c) were reported for people who lived out-of-county or out-of-state and did not belong to SLVHD, (d) were not entered in UT-NEDSS but updated in the previous surveillance system, NETSS, and (e) were not reportable diseases in Utah. We also stratified the reports based on the urgency of reporting. In Utah, diseases are either reported immediately or within three working days. We excluded Tuberculosis cases from the analysis of the immediately reportable cases because the timeliness is longer for Tuberculosis when compared to other diseases due to the length of time it takes for the laboratory results of the test to be obtained (e.g., the result of a skin test takes between 2-3 days).

We calculated the median time delay, interquartile ranges, and identified the % of reports received at public health on the same day as specimen collection, the % of reports received at public health one day after specimen collection, the % of reports received at public health two days after specimen collection, etc. for all six categories of reporting sources. We applied the Wilcoxon rank sum test to test for significance and used $\alpha = 0.05$ to indicate statistical significance.

We also calculated the median delay between transmission of the HL7 IM-LD reports and their receipt at the UDOH. This metric is useful to test the interface between Intermountain and the UDOH.

Completeness of the Content of the Initial Case Report

We compared the completeness of information content of the HL7 IM-LD reports with the paper reports. The source of data for the paper reports for this analysis was the observation study at SLVHD. We did not use the data extracted from UT-NEDSS because data in the surveillance system could change once the case investigation began. We used a data collection form to ensure that we captured the quality of the reports received initially at the health department. We focused on selected data fields that are required for public health triage and investigation such as patient name, patient date of birth, patient telephone number, patient address, patient race, hospitalization status, pregnancy status, laboratory test name, laboratory test results, additional laboratory name and results, reporting contact name, reporting contact phone, and medications. The reporting contact name and phone number were considered complete in the paper-based reports even if they were included in the fax cover-sheet and not explicitly in the report. The completeness of pregnancy status was computed after excluding males and female children younger than 12 years. We excluded reports that were duplicates of previous reports. A report was considered to be a duplicate if it did not contain any new information when compared to previous reports received at public health. We used descriptive statistics and tests for proportions to compare the completeness of information of the electronic reporting process with the completeness of information of the paper-based reporting process.

Completeness of the Electronic Reporting Process

Completeness of the electronic reporting process was assessed by identifying the total number of reports transmitted from IMC and LDS hospitals during the study periods. We calculated (a) the proportion of reports that were transmitted by both the elec-

tronic and the paper-based processes, (b) the proportion of reports transmitted only by the electronic process, and (c) the proportion of reports transmitted only by the paper-based process. We also identified the proportion of HL7 IM-LD reports that were received at the UDOH. This metric is useful to test the interface between the UDOH and Intermountain.

Study Periods

Prospective Study Period

We conducted an observation study at SLVHD for a duration of two weeks from July 7 to 20, 2010. The study involved direct observations during the processing of reports by the triage nurse at SLVHD. For each report received at SLVHD we recorded (a) the date of receipt, (b) if it belonged to SLVHD, (c) if it was a duplicate or an update, and (d) the quality of certain core data fields (described previously). We evaluated the timeliness and completeness of information content in the initial report for each of the six categories of reporting facilities. We also identified the completeness of the electronic reporting process.

Retrospective Study Period

We extracted data from UT-NEDSS for a period of 18 weeks (21st October, 2010 to 23rd February, 2011) using the date that the reports were received at public health. We evaluated the timeliness for each of the six categories of reporting facilities. We also identified the completeness of the electronic reporting process. We did not compute the completeness of information content in the initial report because, as mentioned earlier, once the case investigation begins, the data recorded in UT-NEDSS may differ from what

was sent in the initial report.

We extracted the HL7 IM-LD reports from Intermountain and the UDOH for the same 18 weeks. However, we were unable to extract the HL7 electronic reports from IMC during 30th November and 8th December, 2010.

Results

Description of Reports Received During the Prospective Period

A descriptive summary of the paper and electronic reports in the prospective period is given below:

Paper Reports

During the study period, 322 reports were received at SLVHD. After excluding out-of-county reports (18%) and reports on diseases not reportable in Utah (3%) the number of reports received at SLVHD were 254. Of these 254 reports, we excluded duplicate reports (16%) and reports that contained updated information to already reported cases (18%). Therefore, the total number of new relevant reports used in the analysis was 167. Half of the 167 reports were sent by clinical facilities (53%) and the remaining reports were sent from laboratories (47%). The three most frequently reported diseases were Chlamydia (56%), Tuberculosis (7%), and Giardiasis (6%).

Electronic Reports

During the study period, 39 reports were transmitted electronically from IMC and LDS hospital. After excluding updated reports and cases that are not reportable in Utah,

there were a total of 23 new and relevant reports. The three most frequently reported diseases were Streptococcal Disease (22%), Chlamydia (17%), and Hepatitis C (17%).

Description of Reports Received During the Retrospective Period

A descriptive summary of the paper and electronic reports in the retrospective period is given below:

Paper Reports

During the study period, there were a total number of 3454 cases that belonged to SLVHD and were entered into UT-NEDSS. The reports were first received from clinical facilities (42%), from laboratories (53%), and from other sources (5%). Overall, the three most frequently reported diseases were Chlamydia (35%), Influenza (33%), and Tuberculosis (7%), however the distribution of diseases first reported by laboratories differed from the distribution of those diseases reported by clinical settings. Diseases more likely to be first reported by laboratories than clinical facilities include Chlamydia, Gonorrhea, Hepatitis B, and Syphilis ($p < 0.0001$). Diseases more likely to be reported by clinical facilities than laboratories include Hepatitis C, Streptococcal Disease, and Tuberculosis ($p < 0.0001$). Diseases that are equally likely to be reported first by laboratories and clinical facilities include Campylobacteriosis, Cryptosporidiosis, Haemophilus influenza invasive disease, Hepatitis A, Influenza, Legionellosis, Norovirus, Pertussis, Salmonellosis, and Shigellosis.

Electronic Reports

During the study period, 829 HL7 electronic reports were transmitted from IMC and LDS hospital. After excluding updated reports and cases that are not reportable in

Utah, there were a total of 564 reports. The three most frequently reported diseases were Influenza (38%), Hepatitis C (19%), and Streptococcal Disease (15%).

Metric 1: Timeliness of Reporting

During the prospective study period, the HL7 IM-LD reports were significantly more timely than reports received from Intermountain-other (clinical) and Other (Labs) (p-value < 0.0001). During the retrospective study period, the HL7 IM-LD reports were significantly more timely than the paper-based reports received from all other sources ($p < 0.0001$) except Intermountain (Labs) (Table 6.1). The reports from Intermountain (Labs) were more timely than the HL7 IM-LD reports.

For included diseases that need to be reported immediately, the timeliness of the HL7 IM-LD reports (median delay: 1day) differed significantly from the timeliness of the paper reports received from Other (Labs) (median delay: 7 days; $p < 0.0001$). For diseases that need to be reported within three working days, the HL7 IM-LD reports were more timely than the paper-based reports from all other sources ($p < 0.0001$) except Intermountain (Labs), which was again more timely than the HL7 IM-LD reports. Since every disease has a different time interval between specimen collection and when laboratory results are available, we evaluated the timeliness of reporting for one disease across all six reporting sources. We choose Chlamydia because it was among the most frequently reported diseases in both the prospective and retrospective study periods. Figure 6.2 provides the proportion of Chlamydia reports received by public health on the same day as the specimen collection, one day after specimen collection, two days after specimen collection, and so forth for the retrospective study period. The HL7 IM-LD reports were more timely than the paper-based reports from Intermountain-other (clinical), Other (clin-

ical), and Other (Labs). As was seen in the analysis with all diseases, reports from Intermountain (Labs) were more timely than the HL7 IM-LD reports. The analysis using the prospective study period for Chlamydia reports showed a similar pattern.

During the prospective study period, the HL7 IM-LD reports were received at the UDOH within a minute of being transmitted from Intermountain. During the retrospective study period, the median reporting time was 1 minute, but there was a surprising delay in transmission for 17% of the reports. The delay ranged from 3 hours to 7 days for some of the reports transmitted from Intermountain between December 12th, 2010 and February 3rd, 2011.

Metric 2: Completeness of Information Content in the Initial Report

Table 6.2 describes the completeness of selected data fields for all six categories of reporting sources. Pregnancy status, physician notes, and current antibiotics are not being transmitted in the current phase of implementation of the HL7 electronic reporting system. All other data fields that are currently included in the HL7 IM-LD reports were more complete than the paper-based reports from all other sources. The HL7 IM-LD reports were significantly more complete regarding patient telephone number than Other (Labs) ($p < 0.0001$). The patient address, physician telephone number, and reporting contact name were significantly more complete in the HL7 IM-LD reports than the reports from both Intermountain (Labs) and Other (Labs). The HL7 IM-LD reports included more complete information regarding the hospitalization status of the patient when compared to the reports from Paper IM-LD, Other (clinical), and all laboratories. Pregnancy status from the paper-based reports was also more complete from clinical sources than from laboratory sources.

Metric 3: Completeness of the Electronic Reporting Process

The completeness of reporting was assessed during both the prospective and retrospective study periods using unique reports transmitted from IMC and LDS hospital via both the electronic and paper-based reporting system. During the prospective study period, a total of 27 cases were identified from IMC and LDS hospital. Of these, 85% were reported by both the electronic and the paper-based reporting systems. About 15% of the cases were reported only by the paper-based system and not by the electronic reporting system. These reports were for the following diseases: Hepatitis B, Chlamydia, CJD, and Pertussis. There were no additional reports transmitted by the electronic reporting process during the prospective study period. All the HL7 electronic reports transmitted from IMC and LDS hospitals were received at the UDOH. During the retrospective study period, a total of 584 cases were identified from IMC and LDS hospital. At our first attempt to link the reports, we identified 239 (41%) cases that were reported only by the HL7 IM-LD reporting system and not by the paper-based process. But after a manual search of the UT-NEDSS surveillance system for these 239 cases, we identified 194 cases to be present in UT-NEDSS and 45 (8%) to have been reported only via the electronic reporting system. The reasons why these 194 cases were initially thought to have been transmitted only by the electronic reporting process are: (a) they were included in previous reports received from laboratories and hence not documented as being sent by the IPs from IMC and LDS hospital and (b) they did not belong to SLVHD and hence were not extracted from UT-NEDSS. One of the authors (DR) was only given access to SLVHD cases. Thus, the missing cases that were out-of-county had to be verified by a search in UT-NEDSS by a SLVHD public health official. Figure 6.3 describes the final results of the

completeness of the electronic reporting system and the paper-based reporting system. We identified 32 cases that were reported only by the paper-based system. The cases transmitted only by the paper-based reporting system included Campylobacteriosis, Chlamydia, Hepatitis B Acute, Meningitis Aseptic, Necrotizing Fasciitis, Shigellosis, Tuberculosis Latent Infection, and Influenza-associated hospitalization. In contrast, the cases transmitted only by the HL7 electronic reporting system included Hepatitis B Surface Antibody, Hepatitis A Total Antibody, Streptococcal disease, Hepatitis C Antibody, Influenza H1N1, Western Blot, and Nosocomial Pneumonia. All the 829 HL7 reports transmitted from IMC and LDS hospital were received at the UDOH.

Discussion

We evaluated the HL7 electronic reporting system by comparing the timeliness, completeness of information content, and the completeness of the reporting process using prospective and retrospective study designs. We found that the HL7 IM-LD reports were more timely than the paper-based reports from clinical facilities and Other (Labs). However, the HL7 IM-LD reports were less timely than the paper-based reports from Intermountain (Labs). The HL7 IM-LD reports are generated daily at noon. We believe that the timeliness may improve if they are generated more frequently in a day.

The information included in the HL7 IM-LD reports was more complete than the information included in reports from the other reporting sources. Pregnancy status, physician notes, and current antibiotics will be included in the HL7 IM-LD reports in subsequent phases of implementation. We also found that laboratory reports were not as complete as clinical reports. The more complete the initial reports are the less time the triage

nurse needs to spend gathering the required data. During the observation study, we observed that when a laboratory report was received with incomplete information, the triage nurse waited for the clinical report because it would contain the missing information. Thus, although reports from Intermountain (Labs) were received earlier than the clinical reports, they may not impact the timeliness of case investigation due to incomplete information. Therefore, we believe that resources need to be utilized to improve not just ELR but also electronic case reporting.

The results of the completeness of the electronic reporting process indicate that the detection logic used at Intermountain Healthcare to identify reportable conditions may need to be improved. We identified cases that were detected independently by the IPs (5%: retrospective study period and 15%: prospective study period) and not detected by the automated detection system. Since most of the cases reported by IMC and LDS hospital were transmitted electronically and by the paper-based process, we believe that once the electronic systems are fully implemented, it would be more efficient for the IPs to use their resources to identify cases missed by the electronic system. Examples of such cases would be: toxic shock syndrome (TSS), necrotizing fasciitis, post diarrheal hemolytic uremic syndrome (HUS), and clusters of illness that do not generate laboratory reports. They need not spend valuable resources to re-send reports to public health that are being sent electronically.

We also identified cases that were sent electronically but not reported by the IP process (8%: retrospective study). Since most of these cases were not sent by the IP at IMC but reported electronically on a Thursday this may be due to a workflow related is-

sue at IM. We will follow-up with the IPs to identify the various reasons behind these unreported cases.

Our evaluation has limitations. The timeliness analysis was performed using the specimen collection date and the date the report was received at public health. As mentioned earlier, the time interval between the collection of the specimen and the identification of the test result varies across diseases. We did account for this variation by analyzing all reports for a single disease however it may be more appropriate to calculate the timeliness of reporting based on the date when the laboratory results are identified. Unfortunately, this date is rarely populated in UT-NEDSS.

During this study, we identified several problems with the HL7 electronic messages sent to the UDOH. First, some of the reports included an incorrect specimen collection date indicating that there was a problem with the extraction of the data from the EHR and translation into an HL7 v2.5.1 message. Second, the test results in some of the reports were truncated and are currently being sent as free text. The test result needs to be sent using a SNOMED CT code which may also help with the automated integration with UT-NEDSS. Third, we identified that the transmission of 17% of the reports sent during the retrospective study period was delayed by 3 hours to 7 days. It is not clear whether this delay was caused at Intermountain Healthcare or at the UDOH. A follow-up investigation is required to ensure that this delay is not repeated when the electronic system `goes live'.

In the process of extracting data from UT-NEDSS and performing the analysis, we identified several deficiencies that may impact future quality improvement efforts. We realized that UT-NEDSS stores the date a report is received at public health and the

reporting facility only for the first report received. The date received at public health and the reporting facility are not stored for subsequent reports for the same case. Subsequent reports are scanned and included in UT-NEDSS cases as attachments. As mentioned in the Results section, this made it necessary for us to manually review the scanned documents to (a) identify the appropriate specimen collection date to use for the timeliness analysis and (b) identify whether the IPs had reported the case to public health. As electronic reporting systems are being implemented in the US, it is important for surveillance systems to be able to support ongoing monitoring systems for quality assurance purposes. Thus we recommend that UT-NEDSS store information from subsequent reports in a way that is conducive for automated data extraction and analysis to assess the business processes associated with case reporting and surveillance.

In conclusion, we identified strengths and limitations of the new HL7 electronic case reporting system. This systematic evaluation was critical for understanding the impact of electronic systems on the overall reporting process. We think electronic case reporting systems have the potential to improve the timeliness and completeness of reporting, but ongoing evaluation is required to ensure all relevant cases are being reported. Electronic case reporting also provides opportunities to healthcare facilities to shift the responsibility of the personnel involved in public health reporting from manual reporting of cases to monitoring of patient data to identify unusual cases and outbreaks not detected by laboratory tests.

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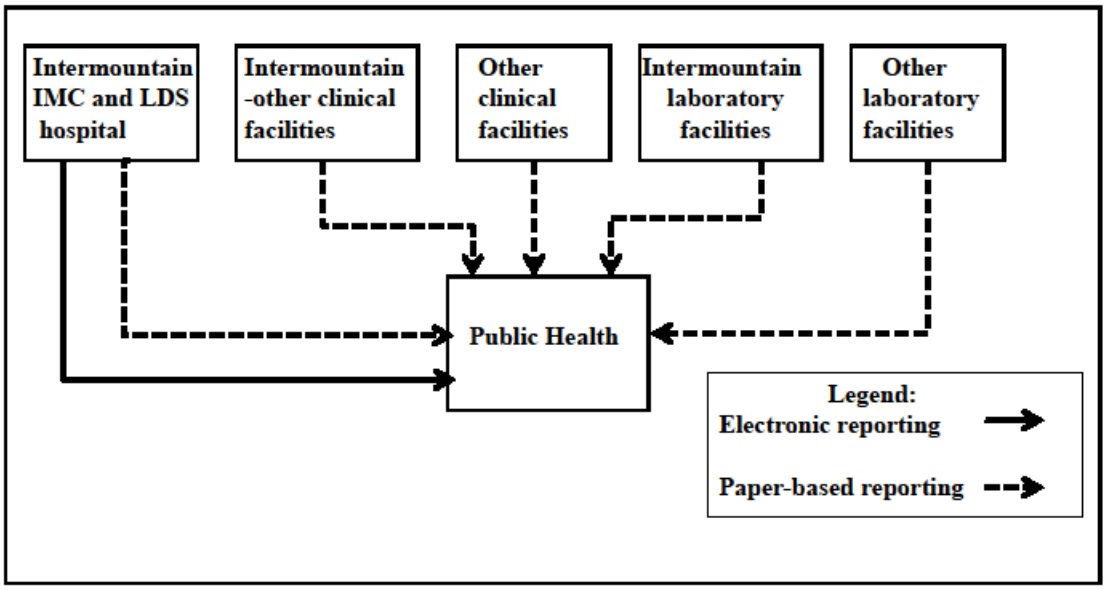

Figure 6.1: Graphical description of the six categories of reporting sources

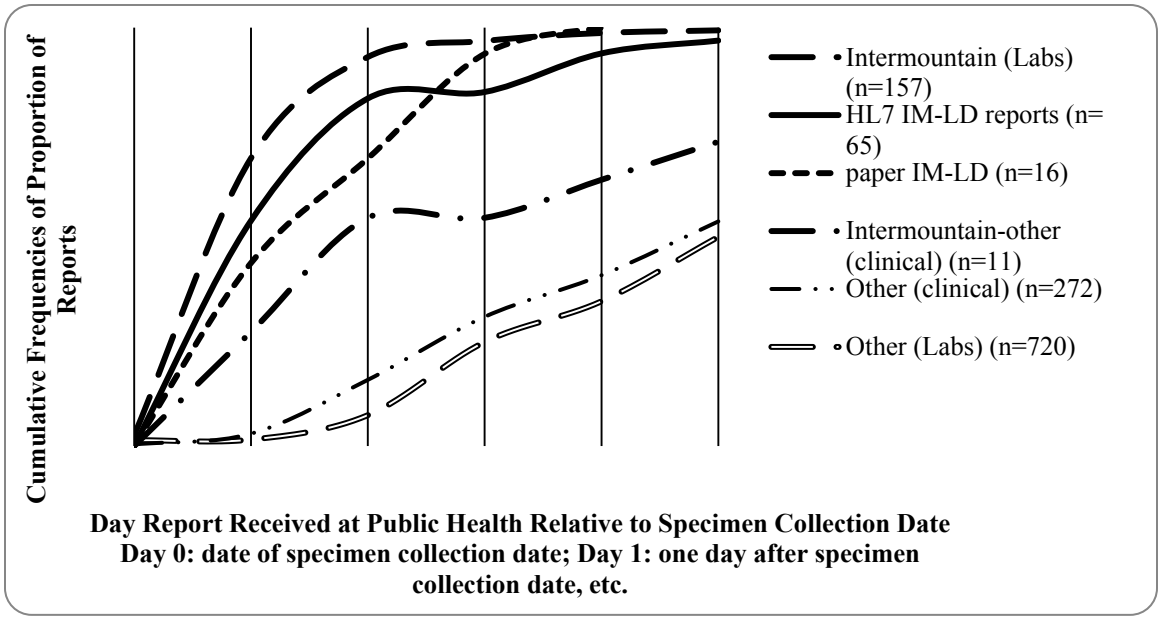

Figure 6.2: Proportion of chlamydia reports received at public health for the retrospective study period

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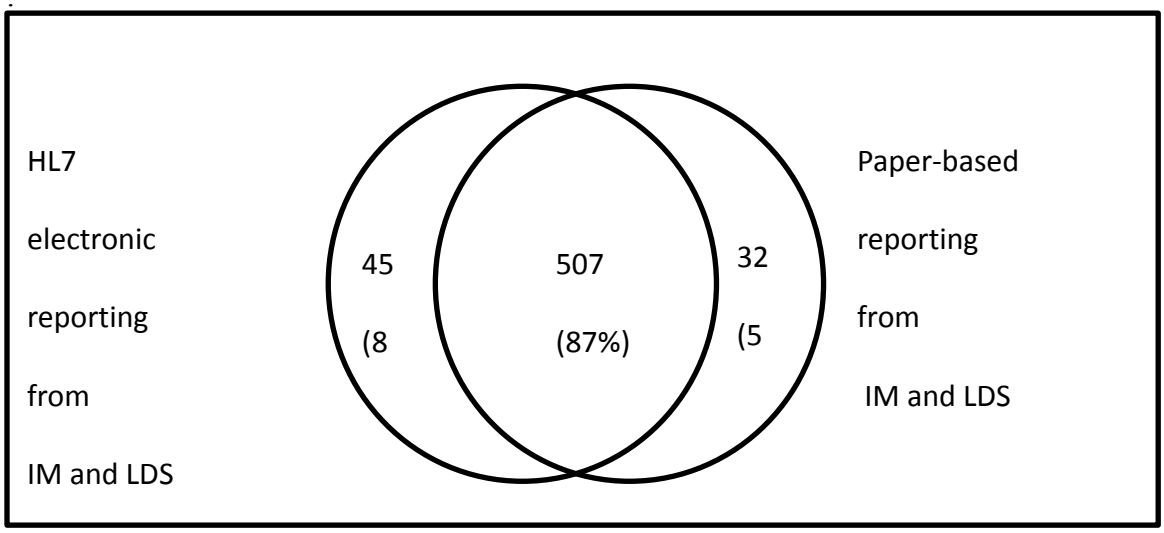

Figure 6.3: Distribution of the 584 unique case reported by the HL7 electronic reporting system and the paper-based reporting system during Oct 21, 2010 – Feb 23, 2011.

Table 6.1: Timeliness of all diseases for the retrospective study period

Reporting Sources	Timeliness		
	N days	Median # days	Interquartile Range in
HL7 IM-LD	536	2	1 to 3
Paper IM-LD	342	2	1 to 4
Intermountain-other (clinical)	195	2	1 to 4
Other (clinical)	882	3.5	1 to 7
Intermountain (Labs)	441	1	1 to 2
Other (Labs)	1387	5	3 to 7

Table 6.2: Completeness of selected data fields for all six categories of reporting sources for the prospective study

	Clinical Sources				Laboratory sources	
Data Fields	HL7 IM-LD N=23	Paper IM-LD (N=34)	Inter-mountain-other (clinical) (N=14)	Other (clini-cal) (N=122)	Intermoun-tain (Labs) (N=59)	Other (Labs) (N=17)
Patient Name	100%	100%	100%	99.18%	100%	100%
Patient DOB	100%	97.06%	100%	98.36%	98.31%	100%
Patient Tel.Phone #	100%	100%	100%	84.43%	98.31%	5.88%*
Patient Ad-dress	100%	85.29%	100%	94.26%	0%*	5.88%*
Patient Race	87%	8.82%*	21.43%*	65.57%	0%*	5.88%*

Table 6.2 (Continued): Completeness of selected data fields for all six categories of reporting sources for the prospective study

	Clinical Sources				Laboratory sources	
Data Fields	HL7 IM-LD N=23	Paper IM-LD (N=34)	Inter-mountain-other (clinical) (N=14)	Other (clinical) (N=122)	Intermountain (Labs) (N=59)	Other (Labs) (N=17)
Pregnancy Status	0%	5.26%	100%	63.15%	0%	0%
Physician Name	100%	100%	71.43%*	96.72%	98.31%	82.35%
Physician Tel.Phone	100%	94.12%	85.71%	86%	0%*	11.76%*
Reporting Contact Name	100%	91.18%	92.86%	91.8%	1.69%*	47.06%*
Reporting Contact Tel.Phone #	100%	94.12%	35.71%*	95.9%	96.61%	35.29%*
Physician Notes	0%	11.76%	14.29%	12.3%	0%	0%
Hospitalization Status	100%	50%*	92.86%	10.65%*	10.17%*	35.29%*
Current Antibiotics	0%	58.82%	85.71%	75.4%	0%	11.76%*
Lab Test Name	100%	97.06%	100%	94.26%	100%	100%
Lab Test Result	100%	97.06%	100%	99.18%	100%	100%
Additional Lab Test Results	100%	94.12%	100%	92.62%	100%	94.12%

*Significantly different from HL7 IM-LD reports

CHAPTER 7

CURRENT STATUS, LESSONS LEARNED, AND RECOMMENDATIONS

The two research areas described in this thesis were developed as projects under the Rocky Mountain Center of Excellence in Public Health Informatics. Part of the mission of the Center of Excellence is to effectively translate public health informatics research into public health practice. Thus, the execution of our research required close collaboration between academic and public health practitioners and researchers. In this chapter, we describe the current status of each area of work, provide a synthesis of the lessons learned during the research process, and recommend next steps to address the implementation and adoption of the two projects in the real world.

Modeling and Development of the Prototype Knowledge Management System for Public Health Reporting

Current Status

The web-based system that was developed is stored at the Center of High Performance and Computing (CHPC) [1] and is accessible using a URL. The usability testing conducted using the web application for public health reporting specifications indicated that several changes are required to meet the needs of the users. The recommendations that can be made without significant changes to the model will be incorporated in the

near future. The current model of the laboratory detection criteria has disadvantages. It is based on a 1-1 mapping between the laboratory test name and the laboratory test result. Since there may be several potential results for a given laboratory test, associating each test name with a specific result will cause problems due to combinatorial explosion. Therefore, the model for the reporting criteria is being modified to include a list of LOINC codes that are associated with a laboratory finding and a list of SNOMED-CT codes associated with laboratory test results consistent with the way value-sets are being published in the Public Health Information Network Vocabulary Access and Distribution Service (PHIN VADS) [2].

The current content included in the prototype public health knowledge management system has been entered by manually populating XML documents. One of the objectives of developing a public health knowledge management system was to develop a better communication tool for public health authorities to publish the reporting specifications. Therefore, an authoring environment that allows public health officials to author, review, publish, and update the reporting specifications is necessary for the success of our endeavors. The Rocky Mountain Center of Excellence research team (including DR), have identified an authoring workflow and are developing an interactive web-based tool using Altova StyleVision [3] that can be used to author the content for the public health reporting system. However, the system is currently not fully functional and user testing of the authoring environment needs to be done to ensure that the authoring workflow meets the needs of the users.

Lessons Learned

The research conducted in this area of work was more complex than expected. During the modeling process of the public health reporting specifications, we realized that there was an immense amount of variation in the specifications across disease, jurisdictions, and type of reporting facilities. As mentioned in Chapter 3, although some variation in the reporting specifications is required (some diseases may not be considered important to track in some parts of the country or some conditions may need increased monitoring of preliminary, not just final results), it is important to recognize that not all variation is required. For example, it is unclear why Colorado and Utah should have the same reporting time frame for laboratories and clinical settings but Washington has different reporting time frames for laboratories and clinical settings. We believe that such widespread variation may contribute to the costs incurred by reporting facilities that are trying to comply with the reporting mandate. Although, we were able to accommodate this variation in the model we developed, we recommend that a collaborative effort be made by public health authorities to identify the concepts in the reporting specifications that can be standardized and thus reduce the effort needed by reporting facilities to comply with the reporting mandate.

Electronic Case Reporting between Intermountain Healthcare and the Utah Department of Health

Current Status

Since 2009, Intermountain Healthcare has been transmitting electronic case reports using Health Level Seven (HL7) v2.5.1 to the UDOH from two hospitals (Intermountain Medical Center and LDS hospital). The reports are currently being stored at the

UDOH in a test environment. In early 2011, the electronic reporting system was extended to 20 additional Intermountain Healthcare hospitals. However, the integration of the electronic case reports with UT-NEDSS, the state-wide surveillance in Utah, is still under development. The messages will need to be integrated into UT-NEDSS before their impact on public health work flow and disease control can be assessed. Currently, the HL7 v2.5.1 message structure is being modified to meet Meaningful Use requirements. For example, the pregnancy status, next of kin information, abnormal flags, reference ranges, and the location of the laboratory are being included in the message structure. In addition, the message structure now includes the SPM segment to transmit specimen-specific information.

Lessons Learned

Research conducted in this area of work is an example of the challenges faced while implementing new informatics solutions in the real world of public health practice. Through collaboration with researchers from the UDOH, Intermountain Healthcare, and the University of Utah, we developed a message structure using HL7 v2.5.1 to transmit clinical and laboratory information as a case report. At that time (and now), electronic case reporting was not a well-researched area. Although Intermountain Healthcare had the necessary infrastructure to transmit the electronic case reports, the UDOH did not have the infrastructure to receive the electronic case reports. While the UDOH was developing the required infrastructure to receive electronic messages from Intermountain Healthcare, several events occurred that changed the priority of the electronic case reporting project for the UDOH. The UDOH developed and implemented a new UT-NEDSS system with an outside contractor (TriSano), the public health personnel involved with

the case reporting project were assigned to other projects, and reporting policies changed (e.g., Meaningful Use compliance) [4]. Currently, there are major efforts by clinical and public health settings to meet the Meaningful Use requirements to send Electronic Laboratory Reports from hospital systems. However, receipt of electronic case reports is no longer a priority and it has been stated that the Meaningful Use requirements pose a significant challenge for local and state public health departments [5]. Figure 7.1 summarizes the electronic case reporting efforts in Utah from 2007 to 2012.

Recommendations

System Adoption

The principles of usability allow researchers to identify problems related to the usability of the system. However, it does not fully measure how the user perceives the system which ultimately affects system adoption. There are several theoretical models available that focus on predicting system adoption. Two of the models that have been commonly used in the literature are the Technology Acceptance Model (TAM) [6] and Task, Technology, and Fit (TTF) [7].

The TAM posits two main constructs: Perceived usefulness and Perceived ease of use. Both these constructs have been shown to measure the user's behavioral intent in the healthcare field [8, 9], thus we expect the model to be applicable in public health. During the usability test sessions with the web application, the response we obtained from the users varied. Some users were very positive about the usefulness of the web-based system but clinical users felt that the system in the current state would not be useful unless the system is integrated into the electronic health record or the knowledge represented in the application can be downloaded to be used in a clinical decision support system. We rec-

ommend that prior to implementation, a survey be conducted among the users in reporting facilities to evaluate their intent to use a system such as the web application for public health reporting specifications. However, it is important to ensure that the questionnaire used to conduct the survey measures concepts that relate to the constructs in the TAM model.

TAM, however, does not incorporate the characteristics of the technology and the tasks that have to be performed using the technology [10]. The TTF model on the other hand includes the characteristics of the system, the task characteristics, and the individual user's skill to predict system adoption [7]. We believe that this model can be used to predict the usage of both the web-application for public health reporting specifications and electronic case reporting. The characteristics of the system relates to the extent to which the system is compatible with other systems that are used as part of the workflow. For the public health knowledge repository, this relates to the integration of the system with the electronic health record. For the electronic case reporting project, this relates to how well the HL7 v2.5 message integrates with the infrastructure being developed at the UDOH to receive ELR (since the UDOH is currently focusing on ELR and not electronic case reporting). Similarly, measuring the task characteristics and the individual skills of the users will help identify adoption of both the public health knowledge repository and electronic case reporting. The web application has been developed based on the tasks that would typically be performed while a user is engaged in public health reporting. It would be an interesting exercise to evaluate the fit of the technology to the tasks performed by the users using the TTF model.

System Implementation

There have been several studies that describe the factors that influence the implementation of systems [11, 12]. We describe the factors that relate to implementation of the electronic case reporting project:

Motivation and Context

The motivation behind the implementation should be user-driven. The electronic case reporting project, although involving the stakeholders from the beginning, had to deal with changing priorities of the project at the UDOH. Context or environment can also affect system implementation. The national push towards a shared surveillance system between local and state health departments justifiably made the UT-NEDSS project a higher priority than the electronic case reporting project. The UT-NEDSS is a state-wide surveillance system that can be accessed by local and state health departments in Utah. The NETSS system that was used prior to the implementation of UT-NEDSS did not allow for data sharing among local and state health departments. Currently the UDOH is focusing on receiving electronic laboratory reporting from a reference laboratory in Utah. Therefore, the current infrastructure being developed in the UDOH to receive electronic reports is based on the data storage requirements of electronic laboratory reporting and not electronic case reporting. Thus, the infrastructure being developed at the UDOH does not currently meet the needs for electronic case reporting.

Funding

The availability of financial resources is one of the most widely recognized factors that contribute to a successful implementation of a system. Public health is a publicly

funded organization and hence funding is always an issue [13]. Implementing a new system in public health is a multi-step process requiring a long-term commitment of resources (monetary, technological, and personnel). The shift in priorities to receive ELR messages is motivated by the financial incentives to hospitals to report laboratory information and the public health department wanting to improve its capability to receive reports from hospitals.

Meeting Information Needs and Providing Value to Users

The system being developed and implemented must meet the users' information needs and should be beneficial to the users. The system should fit to the workflow of the users since systems that adapt to the users' workflow are more likely to be adopted by users. The project goals and definition of success need to be clearly stated and agreed upon by all the concerned parties [11, 12]. The stakeholders from public health entities were involved from the beginning of the electronic case reporting project. We conducted preliminary studies that identified that the triage nurse at a local health department spent approximately 0.25 Full-time-equivalent (FTE) to gather the additional data required before assigning the case for investigation [14]. This suggests that the transmission of more complete case reports would save 0.25 FTE; however this saving would be at the local level, not the state level that controls the priorities of projects.

In conclusion, we believe that system development is a challenging process. However, ensuring that the developed system is implemented and adopted by users is a bigger challenge. We also found that developing systems that require a close collaboration across organizations is not an easy task and a strong commitment from all parties is needed for the project to be successful.

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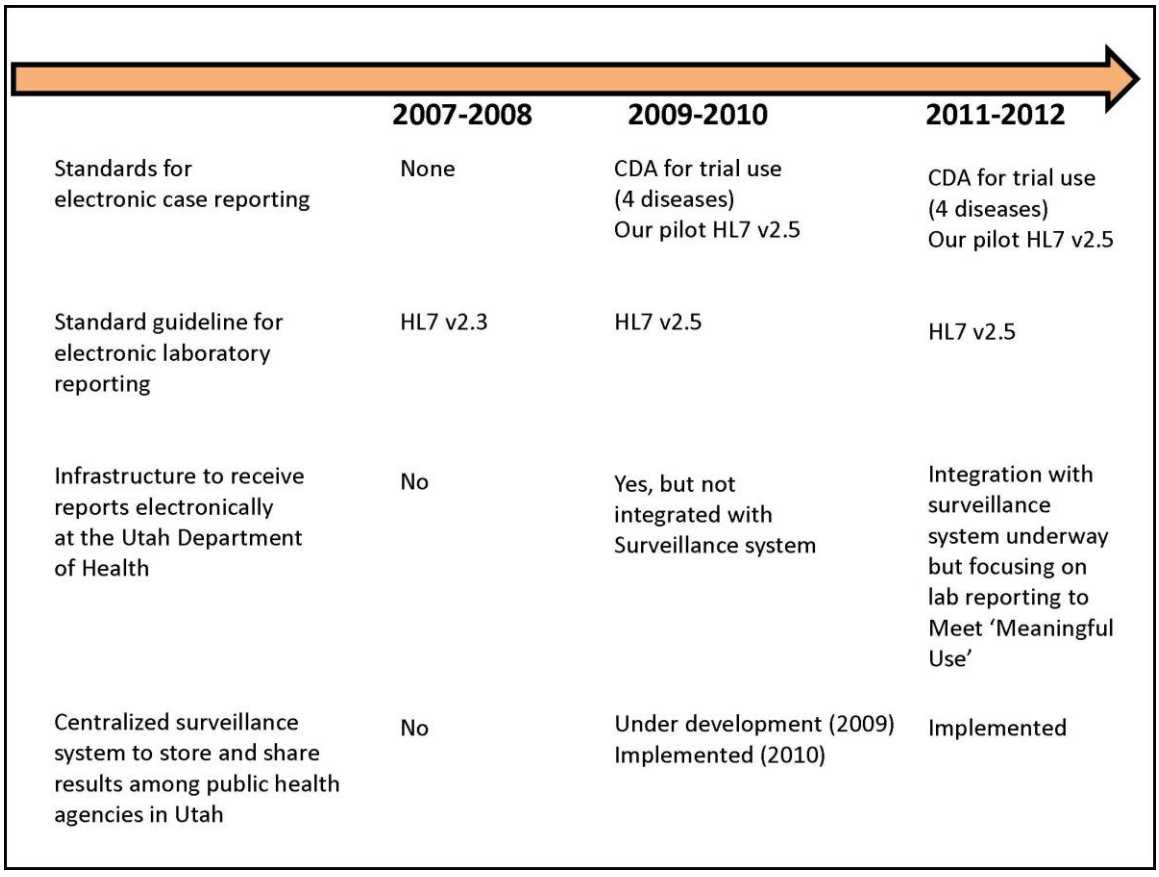

Figure 7.1: Timeline of electronic case reporting efforts in Utah.

CHAPTER 8

CONCLUSION

Public health reporting is an important source of information for public health investigation and surveillance, both of which are necessary for the prevention and control of communicable and non-communicable conditions [1, 2]. Figure 8.1 illustrates the different steps involved in the public health reporting process. The current public health reporting process in the United States includes several problems. Two important disadvantages are (a) the reporting specifications are published by public health departments on individual Websites and (b) most reporting facilities transmit reports to public health entities using manual and paper-based processes.

The research described in this dissertation focuses on the development and evaluation of new strategies to improve the public health reporting process by addressing both these problems. As seen in Figure 8.1, this relates to the five initial steps in the reporting process.

Improving Communication of Public Health Reporting Specifications

To improve the communication of public health reporting specifications by public health authorities, we focused on: (a) examining the business process of a laboratory to comply with the reporting requirements, (b) evaluating public health department Websites to understand the problems faced by reporting facilities when accessing the report-

ing specifications, (c) identifying the content requirements of a knowledge management system for public health reporting specifications, (d) designing the representation of the public health reporting specifications, and (e) evaluating the usability of a prototype web-based application for public health reporting specifications.

We demonstrated that the public health reporting specifications that are displayed on public health department Websites do not fully meet the requirements of the reporting facilities. We also found that laboratories find the lack of a consolidated resource for public health reporting specifications challenging to comply with the reporting requirements.

We identified the concepts required to model the public health reporting specifications and, using input from relevant stakeholders, we ascertained a representation of the content that would meet the needs of the users. We found that users from laboratories and clinical settings had different requirements for the content representation. Thus, showing that the reporting specifications published by public health departments should be specific for the context of the audience. We believe the display of context-specific reporting specifications may help the reporting facilities comply with the mandated reporting requirements. We evaluated the usability of the model we identified to represent the public health reporting specifications with relevant stakeholders using a web-based prototype system. Although we found several usability problems with the interactive application, the model we developed met most needs of the users.

Improving the Transmission of Case Reports from Healthcare Facilities to Public Health Entities

To improve the transmission of case reports from healthcare facilities to public health entities, we focused on: (a) describing public health workflow and identifying re-

quirements for the case report to support workflow, (b) identifying the content of a case report to meet the needs of public health authorities, (c) modeling the case report using HL7 v2.5, and (d) evaluating the electronic case reports by comparing the timeliness, completeness of information content, and the completeness of the reporting process with the paper-based reporting processes.

We identified the content of a case report to support the workflow associated with receiving and investigation of case reports at local health departments and to meet the needs of surveillance practitioners at state health departments. We developed an extendable message model using HL7 v2.5, LOINC, and SNOMED-CT that has been transmitted from Intermountain Healthcare to the Utah Department of Health (UDOH) since 2009. The evaluation conducted in 2011 showed that the HL7 electronic reports transmitted from the Intermountain Healthcare hospitals were more timely (median delay: 2 days) than the paper-based reports from other healthcare enterprises (median delay:3.5 days). However, reports from the Intermountain central laboratory were more timely (median delay: 1 day) than the HL7 electronic reports from the Intermountain Healthcare hospitals. But the HL7 reports were found to include more information than the paper reports from the laboratories. During the observation study conducted at Salt Lake Valley health Department, we observed that the triage nurse would set the laboratory reports aside until the case reports with more complete information were received. Therefore, even though the laboratory reports were received one day earlier, we believe that they may not impact the timeliness of case investigation due to incomplete information. These findings illustrate the need for electronic case reporting and not just electronic laboratory reporting. The analysis of the completeness of the reporting process indicated that most cases were

sent both electronically and via the current paper-based process. Thus, it may be more efficient for the infection preventionists to use their resources to identify cases that do not get detected based on laboratory tests, instead of manually sending all reports to health departments. However, the electronic reports received at the UDOH from Intermountain Healthcare need to be integrated into the state-wide surveillance system (UT-NEDSS) before infection preventionists can stop sending the reports using the paper-based reporting process.

Significance to Biomedical Informatics

The field of Biomedical Informatics includes diverse disciplines that span information from the molecular to the population level [3]. Research in Biomedical informatics involves applications in bioinformatics, clinical informatics, and public health informatics [3]. Public health informatics has been defined as `the systematic application of information and computer science and technology to public health practice, research, and learning' [4]. During the American Medical Informatics Association Public Health Informatics 2011 conference, recommendations for an informatics agenda for public health were identified [5]. Some of the recommendations include (a) the development of a comprehensive set of detailed public health business processes and use cases to guide public health informatics systems development and implementation toward semantic operability and (b) the development and use of effective user-centered design practices in public health informatics system development. The research described in this dissertation involves the use of informatics techniques and tools such as workflow analysis, business process analysis, usability principles and techniques, knowledge engineering, and standards and vocabularies to improve one important aspect of public health practice, namely

public health reporting. These methods directly relate to the informatics agenda for public health that was proposed in 2011. Our research findings have informed national efforts to improve the current process of public health reporting. We demonstrated a model for representing public health reporting specifications and we also proposed a standardized model for the content of an electronic case report using HL7 v2.5 [6]. The metrics and associated data fields used to evaluate the HL7 electronic process may be useful in the design and development of automated QA systems to monitor the quality of public health workflow.

Thus, while these research efforts may not result in widespread implementation, the methods and findings described in this dissertation will inform future efforts to improve public health reporting.

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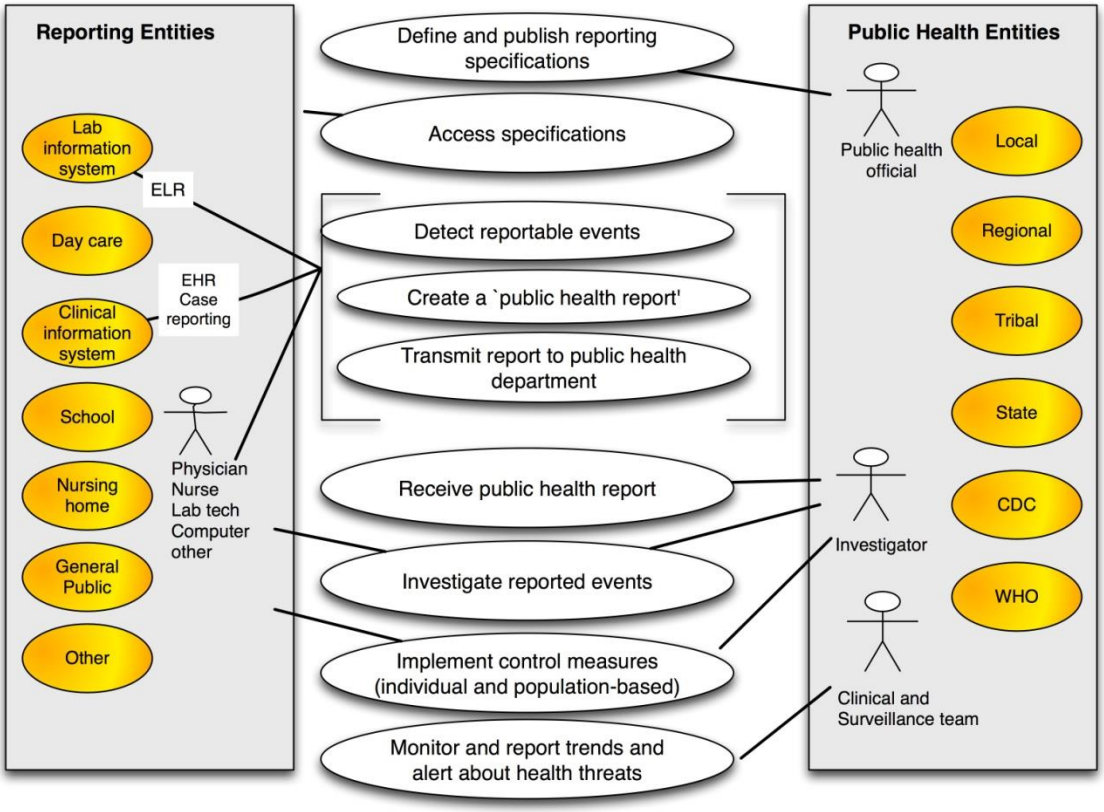


Figure 8.1: Public health reporting use case

APPENDIX A

SCRIPT USED DURING INTERVIEWS WITH PUBLIC HEALTH EPIDEMIOLOGISTS

Scenario: Public health reporting is known to be incomplete and less timely. To improve the reporting process, researchers at the University of Utah are collaborating with Utah, Washington, and Colorado departments of health to develop a prototype knowledge management system. The system would be authored by public health departments with the objective of informing reporting facilities on `what, where, and how' to report diseases. We are currently identifying the content requirements for Group A Strep and Elevated Blood Lead Level. As a public health representative for your state, please answer the following questions with respect to the disease specified above:

1. Which of the following data elements do you think will be important flags to help reporting facilities (laboratories, hospitals, and clinicians) determine if a case is reportable in your state (i.e. what criteria do you want reporting facilities to use)?

   i. Laboratory Test Name

   ii. Laboratory Test Result

   iii. Specimen Source

   iv. Laboratory Test Status (preliminary, final)

   v. Clinical Condition

   vi. Diagnosis Certainty (suspected, confirmed)

vii. Hospitalization Status

viii. Hospitalization Duration

ix. Subject Age Criteria

2. Are there additional data elements that are important to determine if a case is reportable in your state?

3. What are the different resources (disease list, disease rule, other documents, or websites) that the developers of the knowledge management system need to review to identify the reporting specifications?

4. Do public health agencies in your state want laboratories to report cases belonging to non-residents if the laboratory tests are performed in your state?

5. Are laboratories currently not reporting certain laboratory test results? If yes, what are they?

6. From your perspective as a public health official, which of the following data elements are important to be known by a reporting facility to help them comply with the reporting requirement?

i. Reporting Time Frame

ii. URL for Health Department Website

iii. URL for Disease/Injury List

iv. URL for Reportable Condition Form

v. URL for Communicable Disease/Injury Rule

vi. Details on Submission Requirement

vii. Requirement of a Specific Reporting Method

viii. Name and Phone Number of Facility Receiving Report

ix. Name and Phone Number of Facility Receiving Specimen

7. Are there additional data elements that are important for the knowledge management system to provide to reporting facilities?

8. Does the reporting time frame in your state vary by reporting facility (laboratories, hospitals, clinicians, etc.)?

APPENDIX B

SCRIPT USED DURING THE USABILITY TESTING WITH THE MOCK-UP VIEWS

The purpose of this session is to assure that we are developing a user-friendly application for `what's reportable where'. First we would like to ask you for your expert opinion about overall tasks- their completeness and representation. Then, we would like you to comment on details of our initial design. Our overall goal for this session is to make sure that we are representing information that is logical according to the way a user thinks and to assure that the tasks and information are complete. Please answer the following questions:

1. We have thought about these tasks a laboratory or clinician might want to conduct:
    i. Search for one jurisdiction for one condition, e.g., is botulism a reportable condition in Utah.
    ii. Search for all reportable conditions in one jurisdiction.
    iii. Search for all reportable conditions in multiple jurisdictions
2. Have we missed any major tasks users might want to complete for a search of ‘what's reportable where'?
3. We would also like you to comment out loud about our initial design- what works and what does not. We will ask specific questions as we go through the mock-views.

Scenario 1: One state, one condition

i. Please comment on the overall flow and organization of the views. Will they make sense to a laboratory and clinical user?

ii. Do we need more options for `Reporting requirements for:'?

iii. Would you want the view of the list of Reportable Events to be different for laboratories and clinical reporting facilities? E.g., organisms (diseases) for labs and diseases (organisms) for clinicians.

iv. Do you want all options for 'Methods of Reporting' to be displayed with the preferred method being highlighted or do you want the others to be displayed if requested?

v. Apart from what is currently being displayed on the top of the screen as metadata, what other data elements would you want to display?

vi. How would you want to indicate to the user that they can click to obtain more information-using underline or a plus icon or some other method?

vii. For this particular scenario, would you want the details for Reporting Action and Reporting criteria to be displayed but not the details for References?

viii. Are there other elements that you would want to display under Reporting Action?

ix. Are there other elements that you would want to display under Reporting Criteria?

x. For laboratories, would you want to display the laboratory findings before the clinical findings?

xi. For clinicians, would you want to display the clinical findings before the laboratory findings?

xii. Do you want the table of LOINC-SNOMED mapping to be displayed below the corresponding row of the Laboratory findings table or should it be displayed in a different screen?

xiii. Would you want to display the references in a different format?

xiv. Any other comments you would like to share with us?

Scenario 2: One state, all conditions

i. Please comment on the overall organization of the screens. Do they fit with the way a user would be searching for information?

ii. Would you want the user to have the ability to sort the display of reportable event by organism or disease?

iii. Are there additional data elements that you want the user to see?

iv. Do you want any additional sorting capabilities to be provided to the user?

v. Are there other comments you would like to share with us?

Scenario 3: Multiple states, all conditions

Does the information flow make sense to a laboratory or a clinician user?

The current display shows the time frame and the requirement for specimen submission. Would you want any other data elements to be displayed in this view?

APPENDIX C

REPORTING TIME FRAMES FOR EVENTS REPORTABLE IN

COLORADO, UTAH, AND WASHINGTON

		Utah		Colorado			Washington			
	Disease List used and Version	List for Clinical settings and laboratories: June, 2007		List for Provider and hospital: April, 2008 List for Laboratory: April, 2008			List for Provider: December, 2007 List for Hospital: December, 2007 List for Laboratory: June, 2008			
S. No	Reportable Disease/Laboratory Result	Explicitly Reportable?	Clinical/laboratory reporting Stipulated time	Explicitly Reportable?	Provider and Hospital reporting Stipulated time	Laboratory reporting Stipulated time	Explicitly Reportable?	Providers reporting Stipulated time	Hospital reporting Stipulated time	Laboratory reporting Stipulated time
1	Acquired Immune Deficiency Syndrome (AIDS)	Yes	3 days	Yes	7 days		Yes	3 days	3 days	2 days

		Utah		Colorado			Washington			
	Disease List used and Version	List for Clinical settings and laboratories: June, 2007		List for Provider and hospital: April, 2008 List for Laboratory: April, 2008			List for Provider: December, 2007 List for Hospital: December, 2007 List for Laboratory: June, 2008			
S. No	Reportable Disease/Laboratory Result	Explicitly Reportable?	Clinical/laboratory reporting Stipulated time	Explicitly Reportable?	Provider and Hospital reporting Stipulated time	Laboratory reporting Stipulated time	Explicitly Reportable?	Providers reporting Stipulated time	Hospital reporting Stipulated time	Laboratory reporting Stipulated time
	Human Immunodeficiency Virus (HIV)	Yes	3 days	Yes	7 days	7 days	Yes	3 days	3 days	
	Human Immunodeficiency Virus (Western Blot, P-24 antigen, or viral culture)						Yes			2 days
	Human Immunodeficiency Virus (RNA or DNA						Yes			Monthly

		Utah		Colorado			Washington			
	Disease List used and Version	List for Clinical settings and laboratories: June, 2007		List for Provider and hospital: April, 2008 List for Laboratory: April, 2008			List for Provider: December, 2007 List for Hospital: December, 2007 List for Laboratory: June, 2008			
S. No	Reportable Disease/Laboratory Result	Explicitly Reportable?	Clinical/laboratory reporting Stipulated time	Explicitly Reportable?	Provider and Hospital reporting Stipulated time	Laboratory reporting Stipulated time	Explicitly Reportable?	Providers reporting Stipulated time	Hospital reporting Stipulated time	Laboratory reporting Stipulated time
	nucleic acid tests)									
	CD4+ count			Yes (<500/mm 3)		7 days	Yes			Monthly
2	Amebiasis	Yes	3 days							
3	Anthrax	Yes	Immediately	Yes	24 hours		Yes	Immediately	Immediately	
	Bacillus anthracis				Yes	24 hours	Yes			Immediately
4	Arboviral disease	Yes	3 days				Yes	3 days	3 days	2 days

		Utah		Colorado			Washington			
	Disease List used and Version	List for Clinical settings and laboratories: June, 2007		List for Provider and hospital: April, 2008 List for Laboratory: April, 2008			List for Provider: December, 2007 List for Hospital: December, 2007 List for Laboratory: June, 2008			
S. No	Reportable Disease/Laboratory Result	Explicitly Reportable?	Clinical/laboratory reporting Stipulated time	Explicitly Reportable?	Provider and Hospital reporting Stipulated time	Laboratory reporting Stipulated time	Explicitly Reportable?	Providers reporting Stipulated time	Hospital reporting Stipulated time	Laboratory reporting Stipulated time
	Dengue	Yes	3 days				Yes	3 days	3 days	2 days
	St.Louis encephalitis	Yes	3 days	Yes		7 days				
	Western equine encephalitis			Yes		7 days	Yes	3 days	3 days	2 days
	Eastern equine encephalitis			Yes		7 days	Yes	3 days	3 days	2 days
	West Nile Virus Infection	Yes	3 days	Yes (acute)		7 days	Yes	3 days	3 days	2 days
5	Botulism	Yes	Immediately	Yes	24 hours		Yes	Immediately	Immediately	
	Clostridium botulinum			Yes		24 hours	Yes			Immedi-

		Utah		Colorado			Washington			
	Disease List used and Version	List for Clinical settings and laboratories: June, 2007		List for Provider and hospital: April, 2008 List for Laboratory: April, 2008			List for Provider: December, 2007 List for Hospital: December, 2007 List for Laboratory: June, 2008			
S. No	Reportable Disease/Laboratory Result	Explicitly Reportable?	Clinical/laboratory reporting Stipulated time	Explicitly Reportable?	Provider and Hospital reporting Stipulated time	Laboratory reporting Stipulated time	Explicitly Reportable?	Providers reporting Stipulated time	Hospital reporting Stipulated time	Laboratory reporting Stipulated time
										ately
6	Brucellosis	Yes	3 days	Yes	7 days		Yes	Immediately	Immediately	
	Brucella species			Yes		7 days				2 days
7	Campylobacteriosis	Yes	3 days	Yes	7 days		Yes	3 days	3 days	
	Campylobacter species			Yes		7 days				
8	Chancroid	Yes	3 days	Yes	7 days		Yes	3 days	3 days	
	Haemophilus ducreyi			Yes		7 days				
9	Chlamydia tracho-	Yes (infec-	3 days	Yes		7 days	Yes	3 days	3 days	2 days

		Utah		Colorado			Washington			
	Disease List used and Version	List for Clinical settings and laboratories: June, 2007		List for Provider and hospital: April, 2008 List for Laboratory: April, 2008			List for Provider: December, 2007 List for Hospital: December, 2007 List for Laboratory: June, 2008			
S. No	Reportable Disease/Laboratory Result	Explicitly Reportable?	Clinical/laboratory reporting Stipulated time	Explicitly Reportable?	Provider and Hospital reporting Stipulated time	Laboratory reporting Stipulated time	Explicitly Reportable?	Providers reporting Stipulated time	Hospital reporting Stipulated time	Laboratory reporting Stipulated time
	matis	tion)								
10	Cholera	Yes	Immediately	Yes	24 hours		Yes	Immediately	Immediately	Immediately
11	Coccidioidomycosis	Yes	3 days							
12	Colorado Tick Fever	Yes	3 days							
13	Creutzfeldt-Jakob Disease (CJD) and other Transmissible Spongiform En-	Yes	3 days	Yes	7 days					

		Utah		Colorado			Washington			
	Disease List used and Version	List for Clinical settings and laboratories: June, 2007		List for Provider and hospital: April, 2008 List for Laboratory: April, 2008			List for Provider: December, 2007 List for Hospital: December, 2007 List for Laboratory: June, 2008			
S. No	Reportable Disease/Laboratory Result	Explicitly Reportable?	Clinical/laboratory reporting Stipulated time	Explicitly Reportable?	Provider and Hospital reporting Stipulated time	Laboratory reporting Stipulated time	Explicitly Reportable?	Providers reporting Stipulated time	Hospital reporting Stipulated time	Laboratory reporting Stipulated time
	cephalopathies (TSE)									
14	Cryptosporidiosis	Yes	3 days	Yes	7 days		Yes	3 days	3 days	
	Cryptosporidium parvum						Yes			2 days
	Cryptosporidium species			Yes		7 days				
15	Cyclospora infection	Yes	3 days	Yes	7 days	7 days	Yes	3 days	3 days	
	Cyclospora cayetanensis						Yes			2 days

		Utah		Colorado			Washington			
	Disease List used and Version	List for Clinical settings and laboratories: June, 2007		List for Provider and hospital: April, 2008 List for Laboratory: April, 2008			List for Provider: December, 2007 List for Hospital: December, 2007 List for Laboratory: June, 2008			
S. No	Reportable Disease/Laboratory Result	Explicitly Reportable?	Clinical/laboratory reporting Stipulated time	Explicitly Reportable?	Provider and Hospital reporting Stipulated time	Laboratory reporting Stipulated time	Explicitly Reportable?	Providers reporting Stipulated time	Hospital reporting Stipulated time	Laboratory reporting Stipulated time
16	Diphtheria	Yes	Immediately	Yes	24 hours		Yes	Immediately	Immediately	
	Corynebacterium diphtheriae			Yes		24 hours				2 days
17	Echinococcosis	Yes	3 days							
18	Ehrlichiosis	Yes (human granulocytic, human monocytic, or unspec-	3 days							

		Utah		Colorado			Washington			
	Disease List used and Version	List for Clinical settings and laboratories: June, 2007		List for Provider and hospital: April, 2008 List for Laboratory: April, 2008			List for Provider: December, 2007 List for Hospital: December, 2007 List for Laboratory: June, 2008			
S. No	Reportable Disease/Laboratory Result	Explicitly Reportable?	Clinical/laboratory reporting Stipulated time	Explicitly Reportable?	Provider and Hospital reporting Stipulated time	Laboratory reporting Stipulated time	Explicitly Reportable?	Providers reporting Stipulated time	Hospital reporting Stipulated time	Laboratory reporting Stipulated time
		ified)								
19	Encephalitis	Yes	3 days	Yes	7 days					
20	Escherichia coli: shiga toxin producing (STEC) including E. coli O157	Yes	3 days	Yes	7 days	7 days	Yes	Immediately	Immediately	2 days
21	Foodborne						Yes	Imme-	Imme-	-

		Utah		Colorado			Washington			
	Disease List used and Version	List for Clinical settings and laboratories: June, 2007		List for Provider and hospital: April, 2008 List for Laboratory: April, 2008			List for Provider: December, 2007 List for Hospital: December, 2007 List for Laboratory: June, 2008			
S. No	Reportable Disease/Laboratory Result	Explicitly Reportable?	Clinical/laboratory reporting Stipulated time	Explicitly Reportable?	Provider and Hospital reporting Stipulated time	Laboratory reporting Stipulated time	Explicitly Reportable?	Providers reporting Stipulated time	Hospital reporting Stipulated time	Laboratory reporting Stipulated time
	Disease							diately	diately	
22	Giardiasis	Yes	3 days	Yes	7 days		Yes	3 days	3 days	
	Giardia Lamblia			Yes		7 days				
23	Gonorrhea	Yes (sexually transmitted and ophthalmia neonatorum)	3 days	Yes (any site)	7 days		Yes	3 days	3 days	2 days
	Neisseria gonorrhoeae			Yes		7 days	Yes			2 days
24	Granuloma In-						Yes	3 days	3 days	

		Utah		Colorado			Washington			
	Disease List used and Version	List for Clinical settings and laboratories: June, 2007		List for Provider and hospital: April, 2008 List for Laboratory: April, 2008			List for Provider: December, 2007 List for Hospital: December, 2007 List for Laboratory: June, 2008			
S. No	Reportable Disease/Laboratory Result	Explicitly Reportable?	Clinical/laboratory reporting Stipulated time	Explicitly Reportable?	Provider and Hospital reporting Stipulated time	Laboratory reporting Stipulated time	Explicitly Reportable?	Providers reporting Stipulated time	Hospital reporting Stipulated time	Laboratory reporting Stipulated time
	guinale									
25	Haemophilus influenzae, invasive disease	Yes	Immediately	Yes	24 hours		Yes (only cases under 5 years of age)	Immediately	Immediately	
	Haemophilus influenzae - positive culture from a normal sterile site			Yes		24 hours				

		Utah		Colorado			Washington			
	Disease List used and Version	List for Clinical settings and laboratories: June, 2007		List for Provider and hospital: April, 2008 List for Laboratory: April, 2008			List for Provider: December, 2007 List for Hospital: December, 2007 List for Laboratory: June, 2008			
S. No	Reportable Disease/Laboratory Result	Explicitly Reportable?	Clinical/laboratory reporting Stipulated time	Explicitly Reportable?	Provider and Hospital reporting Stipulated time	Laboratory reporting Stipulated time	Explicitly Reportable?	Providers reporting Stipulated time	Hospital reporting Stipulated time	Laboratory reporting Stipulated time
26	Hantavirus	Yes (pulmonary syndrome)	3 days	Yes	7 days	7 days	Yes (pulmonary syndrome)	3 days	3 days	
27	Hemolytic Uremic Syndrome	Yes (post-diarrheal)	3 days	Yes (<= 18 years)	7 days		Yes	Immediately	Immediately	
28	Hepatitis A	Yes	Immediately	Yes	24 hours		Yes (acute)	Immediately	Immediately	
	Hepatitis A - positive IgM anti-HAV serologic test			Yes		24 hours	Yes			2 days

		Utah		Colorado			Washington			
	Disease List used and Version	List for Clinical settings and laboratories: June, 2007		List for Provider and hospital: April, 2008 List for Laboratory: April, 2008			List for Provider: December, 2007 List for Hospital: December, 2007 List for Laboratory: June, 2008			
S. No	Reportable Disease/Laboratory Result	Explicitly Reportable?	Clinical/laboratory reporting Stipulated time	Explicitly Reportable?	Provider and Hospital reporting Stipulated time	Laboratory reporting Stipulated time	Explicitly Reportable?	Providers reporting Stipulated time	Hospital reporting Stipulated time	Laboratory reporting Stipulated time
29	Hepatitis B	Yes (cases and carriers)	3 days	Yes	7 days		Yes (acute)	3 days	3 days	
	Hepatitis B (Chronic, initial diagnosis only)						Yes	1 month	1 month	
	Hepatitis B (surface antigen positive)			Yes		7 days	Yes (for pregnant women)	3 days	3 days	
	Hepatitis B (detection of viral antigen, antibody,						Yes			Monthly

		Utah		Colorado			Washington			
	Disease List used and Version	List for Clinical settings and laboratories: June, 2007		List for Provider and hospital: April, 2008 List for Laboratory: April, 2008			List for Provider: December, 2007 List for Hospital: December, 2007 List for Laboratory: June, 2008			
S. No	Reportable Disease/Laboratory Result	Explicitly Reportable?	Clinical/laboratory reporting Stipulated time	Explicitly Reportable?	Provider and Hospital reporting Stipulated time	Laboratory reporting Stipulated time	Explicitly Reportable?	Providers reporting Stipulated time	Hospital reporting Stipulated time	Laboratory reporting Stipulated time
	or nucleic acid)									
30	Hepatitis C	Yes (Acute or Chronic)	3 days	Yes (acute)	7 days		Yes (acute and chronic-initial diagnosis only)	1 month	1 month	Monthly
	Hepatitis C, positive serum antibody titer, including signal to cut-off			Yes		7 days				

		Utah		Colorado			Washington			
	Disease List used and Version	List for Clinical settings and laboratories: June, 2007		List for Provider and hospital: April, 2008 List for Laboratory: April, 2008			List for Provider: December, 2007 List for Hospital: December, 2007 List for Laboratory: June, 2008			
S. No	Reportable Disease/Laboratory Result	Explicitly Reportable?	Clinical/laboratory reporting Stipulated time	Explicitly Reportable?	Provider and Hospital reporting Stipulated time	Laboratory reporting Stipulated time	Explicitly Reportable?	Providers reporting Stipulated time	Hospital reporting Stipulated time	Laboratory reporting Stipulated time
	ratio or more specific positive tests									
31	Hepatitis, Other viral	Yes (non Hep A, non Hep B, non Hep C)	3 days	Yes (non Hep A, non Hep B, non Hep C)	7 days		Yes (non Hep A, non Hep B, non Hep C)	3 days	3 days	

		Utah		Colorado			Washington			
	Disease List used and Version	List for Clinical settings and laboratories: June, 2007		List for Provider and hospital: April, 2008 List for Laboratory: April, 2008			List for Provider: December, 2007 List for Hospital: December, 2007 List for Laboratory: June, 2008			
S. No	Reportable Disease/Laboratory Result	Explicitly Reportable?	Clinical/laboratory reporting Stipulated time	Explicitly Reportable?	Provider and Hospital reporting Stipulated time	Laboratory reporting Stipulated time	Explicitly Reportable?	Providers reporting Stipulated time	Hospital reporting Stipulated time	Laboratory reporting Stipulated time
32	Herpes						Yes (Simplex, Genital & neonatal (initial infection)	3 days	NA	
33	Immunization reactions	Yes (adverse event after small pox vaccination)	3 days				Yes (severe, adverse)	3 days	3 days	

		Utah		Colorado			Washington			
	Disease List used and Version	List for Clinical settings and laboratories: June, 2007		List for Provider and hospital: April, 2008 List for Laboratory: April, 2008			List for Provider: December, 2007 List for Hospital: December, 2007 List for Laboratory: June, 2008			
S. No	Reportable Disease/Laboratory Result	Explicitly Reportable?	Clinical/laboratory reporting Stipulated time	Explicitly Reportable?	Provider and Hospital reporting Stipulated time	Laboratory reporting Stipulated time	Explicitly Reportable?	Providers reporting Stipulated time	Hospital reporting Stipulated time	Laboratory reporting Stipulated time
34	Influenza-associated hospitalization	Yes	3 days	Yes	7 days		No		No time frame specified	
35	Influenza-associated death in a person less than 18 years of age	Yes	3 days	Yes	7 days					
36	Kawasaki Syndrome			Yes	7 days					
37	Legionellosis	Yes	3 days	Yes	7 days		Yes	3 days	3 days	
	Legionella species			Yes		7 days				

		Utah		Colorado			Washington			
	Disease List used and Version	List for Clinical settings and laboratories: June, 2007		List for Provider and hospital: April, 2008 List for Laboratory: April, 2008			List for Provider: December, 2007 List for Hospital: December, 2007 List for Laboratory: June, 2008			
S. No	Reportable Disease/Laboratory Result	Explicitly Reportable?	Clinical/laboratory reporting Stipulated time	Explicitly Reportable?	Provider and Hospital reporting Stipulated time	Laboratory reporting Stipulated time	Explicitly Reportable?	Providers reporting Stipulated time	Hospital reporting Stipulated time	Laboratory reporting Stipulated time
38	Leprosy (Hansen's Disease)	Yes	3 days	Yes	7 days					
39	Leptospirosis						Yes	3 days	3 days	
40	Listeriosis	Yes	3 days	Yes	7 days		Yes	Immediately	Immediately	2 days
	Listeria monocytogenes			Yes		7 days	Yes			2 days
41	Lyme Disease	Yes	3 days	Yes	7 days		Yes	3 days	3 days	
	Borellia burgdorferi			Yes		7 days				
42	Lymphogranuloma venereum			Yes	7 days		Yes	3 days	3 days	

		Utah		Colorado			Washington			
	Disease List used and Version	List for Clinical settings and laboratories: June, 2007		List for Provider and hospital: April, 2008 List for Laboratory: April, 2008			List for Provider: December, 2007 List for Hospital: December, 2007 List for Laboratory: June, 2008			
S. No	Reportable Disease/Laboratory Result	Explicitly Reportable?	Clinical/laboratory reporting Stipulated time	Explicitly Reportable?	Provider and Hospital reporting Stipulated time	Laboratory reporting Stipulated time	Explicitly Reportable?	Providers reporting Stipulated time	Hospital reporting Stipulated time	Laboratory reporting Stipulated time
43	Malaria	Yes	3 days	Yes	7 days		Yes	3 days	3 days	
	Plasmodium species			Yes		7 days				
44	Measles (Rubeola)	Yes	Immediately	Yes	24 hours	24 hours (acute infection)	Yes	Immediately	Immediately	Immediately
45	Meningitis	Yes	3 days	Yes (aseptic)	7 days					
46	Meningococcal Disease	Yes	Immediately				Yes	Immediately	Immediately	

		Utah		Colorado			Washington			
	Disease List used and Version	List for Clinical settings and laboratories: June, 2007		List for Provider and hospital: April, 2008 List for Laboratory: April, 2008			List for Provider: December, 2007 List for Hospital: December, 2007 List for Laboratory: June, 2008			
S. No	Reportable Disease/Laboratory Result	Explicitly Reportable?	Clinical/laboratory reporting Stipulated time	Explicitly Reportable?	Provider and Hospital reporting Stipulated time	Laboratory reporting Stipulated time	Explicitly Reportable?	Providers reporting Stipulated time	Hospital reporting Stipulated time	Laboratory reporting Stipulated time
	Neisseria meningitidis			Yes	24 hours (invasive disease)	24 hours (+ve culture or Gram-negative diplococci from a normally sterile site)				2 days (isolates from normally sterile sites)

		Utah		Colorado			Washington			
	Disease List used and Version	List for Clinical settings and laboratories: June, 2007		List for Provider and hospital: April, 2008 List for Laboratory: April, 2008			List for Provider: December, 2007 List for Hospital: December, 2007 List for Laboratory: June, 2008			
S. No	Reportable Disease/Laboratory Result	Explicitly Reportable?	Clinical/laboratory reporting Stipulated time	Explicitly Reportable?	Provider and Hospital reporting Stipulated time	Laboratory reporting Stipulated time	Explicitly Reportable?	Providers reporting Stipulated time	Hospital reporting Stipulated time	Laboratory reporting Stipulated time
47	Mumps	Yes	3 days	Yes	7 days	7 days	Yes	3 days	3 days	
48	Norovirus infection	Yes	3 days							
49	Paralytic Shellfish Poisoning						Yes	Immediately	Immediately	
50	Pelvic Inflammatory Disease (PID)	Yes	3 days							
51	Pertussis	Yes	3 days	Yes	24 hours		Yes	Immediately	Immediately	
	Bordetella pertussis			Yes		24 hours				2 days
52	Plague	Yes	Immediately	Yes	24 hours		Yes	Immediate-	Immediate-	Immedi-

		Utah		Colorado			Washington			
	Disease List used and Version	List for Clinical settings and laboratories: June, 2007		List for Provider and hospital: April, 2008 List for Laboratory: April, 2008			List for Provider: December, 2007 List for Hospital: December, 2007 List for Laboratory: June, 2008			
S. No	Reportable Disease/Laboratory Result	Explicitly Reportable?	Clinical/laboratory reporting Stipulated time	Explicitly Reportable?	Provider and Hospital reporting Stipulated time	Laboratory reporting Stipulated time	Explicitly Reportable?	Providers reporting Stipulated time	Hospital reporting Stipulated time	Laboratory reporting Stipulated time
								ly	ly	ately
53	Poliomyelitis	Yes (Paralytic)	Immediately	Yes	24 hours	24 hours	Yes	Immediately	Immediately	
54	Polio virus infection	Yes (non-paralytic)	3 days							
55	Psittacosis	Yes	3 days	Yes	7 days		Yes	3 days	3 days	
	Chlamydia psittaci			Yes		7 days				
56	Q Fever	Yes	3 days	Yes	7 days	7 days	Yes	3 days	3 days	
57	Rabies	Yes (Human or Animal)	Immediately	Yes (human, suspected)	24 hours	24 hours	Yes	Immediately	Immediately	Immediately

		Utah		Colorado			Washington			
	Disease List used and Version	List for Clinical settings and laboratories: June, 2007		List for Provider and hospital: April, 2008 List for Laboratory: April, 2008			List for Provider: December, 2007 List for Hospital: December, 2007 List for Laboratory: June, 2008			
S. No	Reportable Disease/Laboratory Result	Explicitly Reportable?	Clinical/laboratory reporting Stipulated time	Explicitly Reportable?	Provider and Hospital reporting Stipulated time	Laboratory reporting Stipulated time	Explicitly Reportable?	Providers reporting Stipulated time	Hospital reporting Stipulated time	Laboratory reporting Stipulated time
58	Rabies Post-Exposure Prophylaxis						Yes	3 days	3 days	
59	Relapsing Fever	Yes (tick or louse borne)	3 days	Yes	7 days	7 days (Borrelia species)	Yes (Borreliosis)	Immediately	Immediately	
60	Rocky Mountain Spotted Fever	Yes	3 days	Yes	7 days	7 days				
61	Rubella (German Measles)	Yes	Immediately	Yes	24 hours	24 hours (acute infection)	Yes	Immediately	Immediately	

		Utah		Colorado			Washington			
	Disease List used and Version	List for Clinical settings and laboratories: June, 2007		List for Provider and hospital: April, 2008 List for Laboratory: April, 2008			List for Provider: December, 2007 List for Hospital: December, 2007 List for Laboratory: June, 2008			
S. No	Reportable Disease/Laboratory Result	Explicitly Reportable?	Clinical/laboratory reporting Stipulated time	Explicitly Reportable?	Provider and Hospital reporting Stipulated time	Laboratory reporting Stipulated time	Explicitly Reportable?	Providers reporting Stipulated time	Hospital reporting Stipulated time	Laboratory reporting Stipulated time
	Rubella, Congenital	Yes	3 days	Yes	7 days		Yes	Immediately	Immediately	
62	Salmonellosis	Yes	3 days	Yes	7 days		Yes	Immediately	Immediately	
	Salmonella Species			Yes		7 days	Yes			2 days
63	SARS (Severe Acute Respiratory Syn-Syndrome)	Yes	Immediately	Yes	24 hours					
	SARS-coronovirus			Yes		24 hours				
64	Shigellosis	Yes	3 days	Yes	7 days		Yes	Immediate-	Immediate-	

		Utah		Colorado			Washington			
	Disease List used and Version	List for Clinical settings and laboratories: June, 2007		List for Provider and hospital: April, 2008 List for Laboratory: April, 2008			List for Provider: December, 2007 List for Hospital: December, 2007 List for Laboratory: June, 2008			
S. No	Reportable Disease/Laboratory Result	Explicitly Reportable?	Clinical/laboratory reporting Stipulated time	Explicitly Reportable?	Provider and Hospital reporting Stipulated time	Laboratory reporting Stipulated time	Explicitly Reportable?	Providers reporting Stipulated time	Hospital reporting Stipulated time	Laboratory reporting Stipulated time
								ly	ly	
	Shigella Species			Yes		7 days				2 days
65	Smallpox	Yes	Immediately	Yes	24 hours	24 hours	Yes	Immediately	Immediately	Immediately
66	Staphylococcus aureus with resistance (VRSA) or intermediate resistance (VISA) to vancomycin isolated from any	Yes	Immediately	Yes		7 days				

		Utah		Colorado			Washington			
	Disease List used and Version	List for Clinical settings and laboratories: June, 2007		List for Provider and hospital: April, 2008 List for Laboratory: April, 2008			List for Provider: December, 2007 List for Hospital: December, 2007 List for Laboratory: June, 2008			
S. No	Reportable Disease/Laboratory Result	Explicitly Reportable?	Clinical/laboratory reporting Stipulated time	Explicitly Reportable?	Provider and Hospital reporting Stipulated time	Laboratory reporting Stipulated time	Explicitly Reportable?	Providers reporting Stipulated time	Hospital reporting Stipulated time	Laboratory reporting Stipulated time
	site									
67	Streptococcal disease (invasive, organism isolated from a normally sterile site)	Yes	3 days							

		Utah		Colorado			Washington			
	Disease List used and Version	List for Clinical settings and laboratories: June, 2007		List for Provider and hospital: April, 2008 List for Laboratory: April, 2008			List for Provider: December, 2007 List for Hospital: December, 2007 List for Laboratory: June, 2008			
S. No	Reportable Disease/Laboratory Result	Explicitly Reportable?	Clinical/laboratory reporting Stipulated time	Explicitly Reportable?	Provider and Hospital reporting Stipulated time	Laboratory reporting Stipulated time	Explicitly Reportable?	Providers reporting Stipulated time	Hospital reporting Stipulated time	Laboratory reporting Stipulated time
68	Streptococcus pneumoniae			Yes (positive culture from a normally sterile site)		7 days				
69	Syphilis	Yes (primary or secondary)	Immediately	Yes (early (1^o, 2^o, early latent))	24 hours		Yes (congenital)	3 days	3 days	

		Utah		Colorado			Washington			
	Disease List used and Version	List for Clinical settings and laboratories: June, 2007		List for Provider and hospital: April, 2008 List for Laboratory: April, 2008			List for Provider: December, 2007 List for Hospital: December, 2007 List for Laboratory: June, 2008			
S. No	Reportable Disease/Laboratory Result	Explicitly Reportable?	Clinical/laboratory reporting Stipulated time	Explicitly Reportable?	Provider and Hospital reporting Stipulated time	Laboratory reporting Stipulated time	Explicitly Reportable?	Providers reporting Stipulated time	Hospital reporting Stipulated time	Laboratory reporting Stipulated time
		Yes (early latent, latent, and congenital)	3 days							
	Treponema pallidum			Yes		24 hours				2 days
70	Tetanus	Yes	3 days	Yes	7 days		Yes	3 days	3 days	
71	Toxic Shock Syndrome	Yes (staphylococcal or streptococ coc-	3 days	Yes	7 days					

		Utah		Colorado			Washington			
	Disease List used and Version	List for Clinical settings and laboratories: June, 2007		List for Provider and hospital: April, 2008 List for Laboratory: April, 2008			List for Provider: December, 2007 List for Hospital: December, 2007 List for Laboratory: June, 2008			
S. No	Reportable Disease/Laboratory Result	Explicitly Reportable?	Clinical/laboratory reporting Stipulated time	Explicitly Reportable?	Provider and Hospital reporting Stipulated time	Laboratory reporting Stipulated time	Explicitly Reportable?	Providers reporting Stipulated time	Hospital reporting Stipulated time	Laboratory reporting Stipulated time
		cal)								
72	Trichinosis	Yes	3 days	Yes	7 days		Yes	3 days	3 days	
73	Tuberculosis	Yes	Immediately	Yes (active disease)	24 hours		Yes	Immediately	Immediately	
	Mycobacterium tuberculosis			Yes (including +ve AFB sputum smears)		24 hours	Yes			2 days

		Utah		Colorado			Washington			
	Disease List used and Version	List for Clinical settings and laboratories: June, 2007		List for Provider and hospital: April, 2008 List for Laboratory: April, 2008			List for Provider: December, 2007 List for Hospital: December, 2007 List for Laboratory: June, 2008			
S. No	Reportable Disease/Laboratory Result	Explicitly Reportable?	Clinical/laboratory reporting Stipulated time	Explicitly Reportable?	Provider and Hospital reporting Stipulated time	Laboratory reporting Stipulated time	Explicitly Reportable?	Providers reporting Stipulated time	Hospital reporting Stipulated time	Laboratory reporting Stipulated time
	Positive TB skin test in workers exposed to active diseases			Yes	7 days					
74	Tularemia	Yes	Immediately	Yes	7 days		Yes	3 days	3 days	
	Francisella tularensis			Yes		7 days	Yes			2 days
75	Typhoid	Yes (cases and carriers)	Immediately	Yes	24 hours					
	Salmonella Typhi			Yes		24 hours				
76	Typhus						Yes	Immediate-	Immediate-	

		Utah		Colorado			Washington			
	Disease List used and Version	List for Clinical settings and laboratories: June, 2007		List for Provider and hospital: April, 2008 List for Laboratory: April, 2008			List for Provider: December, 2007 List for Hospital: December, 2007 List for Laboratory: June, 2008			
S. No	Reportable Disease/Laboratory Result	Explicitly Reportable?	Clinical/laboratory reporting Stipulated time	Explicitly Reportable?	Provider and Hospital reporting Stipulated time	Laboratory reporting Stipulated time	Explicitly Reportable?	Providers reporting Stipulated time	Hospital reporting Stipulated time	Laboratory reporting Stipulated time
								ly	ly	
77	Varicella	Yes	3 days	Yes	7 days					
	Varicella-zoster			Yes		7 days				
78	Vibriosis	Yes	3 days				Yes	3 days	3 days	
	Vibrio cholerae			Yes		24 hours	Yes			Immediately
79	Vibrio non-cholera			Yes		7 days				
80	Viral hemorrhagic fever	Yes	Immediately							
81	Yellow Fever	Yes	Immediately				Yes	Immediately	Immediately	2 days

		Utah		Colorado			Washington			
	Disease List used and Version	List for Clinical settings and laboratories: June, 2007		List for Provider and hospital: April, 2008 List for Laboratory: April, 2008			List for Provider: December, 2007 List for Hospital: December, 2007 List for Laboratory: June, 2008			
S. No	Reportable Disease/Laboratory Result	Explicitly Reportable?	Clinical/laboratory reporting Stipulated time	Explicitly Reportable?	Provider and Hospital reporting Stipulated time	Laboratory reporting Stipulated time	Explicitly Reportable?	Providers reporting Stipulated time	Hospital reporting Stipulated time	Laboratory reporting Stipulated time
82	Yersiniosis						Yes	3 days	3 days	
	Yersinia pestis			Yes		24 hours				Immediately

APPENDIX D

EXAMPLE OF TEST CASES COMPILED TO SUPPORT THE

DEVELOPMENT OF THE WEB-BASED SYSTEM

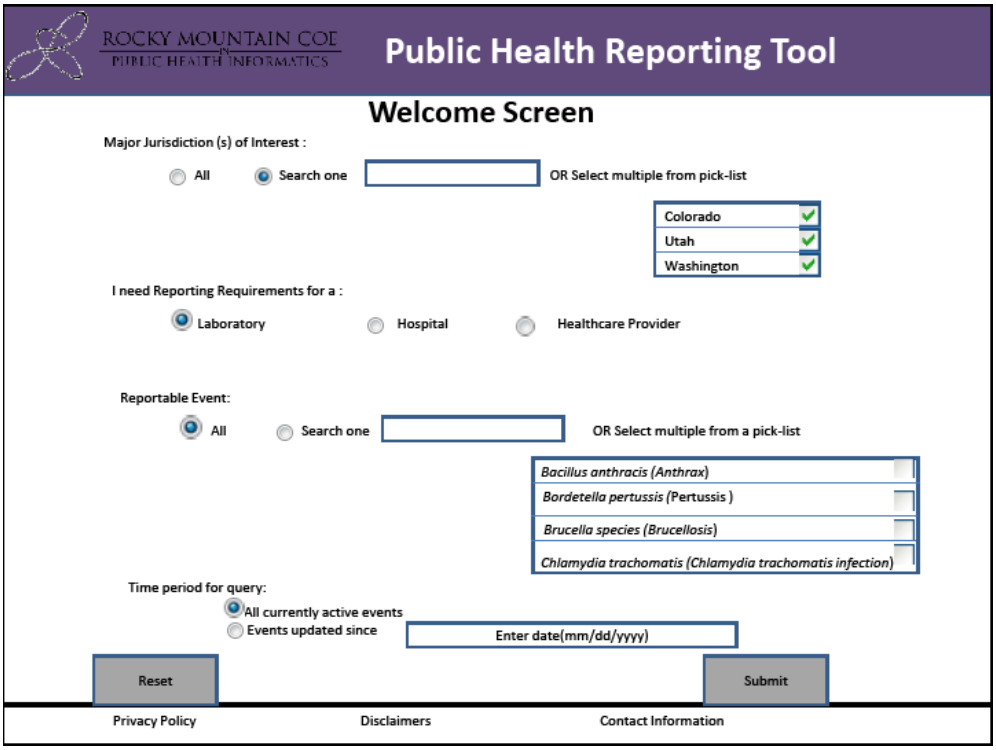
Test Case for the 'Query Screen' for Views

Use case:	Test case for testing the functionality of the "Query screen".	
Goal in Context:	To test functionality on the 'Welcome' screen.	
Scope:	Knowledge Viewing Tool	
Actors:	The users from the reporting facilities and public health entities.	
Priority:	1	
Frequency:	Multiple times a month	
Pre-Conditions:	A database exists and instances of public health reporting specifications in xml have been created, including several Reportable Events and their associated 'reporting criteria' and 'reporting actions'. The user can access the application.	
Success End Condition:	The query submitted by the user gives him the expected output (For e.g., the user submits the following query: Major Jurisdiction of Interest: Utah, Reporting requirements for a laboratory, Reportable event: Chlamydia trachomatis. The application will output the reporting specifications for laboratories reporting Chlamydia trachomatis in Utah. The specifications include the reporting methods, specimen submission requirements, laboratory findings, and references).	
Failed End Condition:	An appropriate error is displayed to the user	
Trigger:	A query submitted by a user (developer or reporting facility)	
Display Requirements for Query Screen		
		The welcome screen has three panels: -Logo and Title panel (top) -Query panel (middle) -Information panel (bottom)
		In the Logo and Title panel, Display the logo and the title "Public

		Health Reporting Tool"
		Query panel: Display the following text: "Welcome Screen", four queries (see Figure 1), and two actionable buttons "Reset" and "Submit".
		Information panel: Display the "Privacy Policy", "Disclaimers", and "Contact Information".
Testing the following query: *Major jurisdiction of interest: Utah* *Reporting Requirements for: Laboratory* *Reportable Events: Chlamydia trachomatis* *Time period: All currently active events*		
Step	**Action**	**Description**
1.1	The user accesses the application	The welcome screen is displayed.
1.2	The user selects the "Major jurisdiction of interest"	
1.2.1	The user clicks on "Search one" or "selects multiple jurisdiction", e.g., Utah	A drop-down box displays and if the user starts typing a value, suggestions for jurisdictions are displayed.
1.3	The user selects the entity for which reporting requirements are needed. The available options are: Laboratory, Hospital, and Healthcare Provider	
1.3.1	The user selects "Laboratory"	
1.4	The user selects the Reportable event.	
1.4.1	The user clicks on "Search one" or "selects from a pick-list", e.g., Chlamydia trachomatis	A drop-down box of organisms is displayed and if the user starts typing a value, suggestions for reportable organisms should be displayed.
1.5	The user specifies a time period for which the query applies.	
1.5.1	The user selects "All currently active events" from "Time Period for query"	All currently active reportable events are displayed-
1.6	The user clicks on "Submit"	The query is submitted
1.7	The user clicks on "Reset"	The pre-selected entries on the welcome

		screen are cleared
Testing the following query: *Major jurisdiction of interest: Utah, Colorado, Washington* *Reporting Requirements for: Laboratory* *Reportable Events: All* *Time period: Events updated since "specific date"*		
Step	**Action**	**Description**
2.1	The user accesses the application	The welcome screen is displayed.
2.2	The user selects the "Major jurisdiction of interest"	
2.2.1	The user clicks on "Select multiple from pick-list", e.g., Utah, Colorado, Washington	A drop-down box displays and the user can scroll through the list and select the jurisdictions of interest
2.3	The user selects the entity for which reporting requirements are needed. The available options are: Laboratory, Hospital, and Healthcare Provider	
2.3.1	The user selects "Laboratory"	
2.4	The user selects the Reportable event.	
2.4.1	The user clicks on "All"	All reportable events for the selected jurisdictions are displayed when the query is submitted
2.5	The user specifies a time period for which the query applies.	
2.5.1	The user selects "Events updated since", e.g., 08/01/2009	All events updated since 08/01/2009 are displayed
Technical details		
Associated Step	**Technical note**	
1.3	The role should be extracted from Reportable Event header/ contextOfUse/role/roleCD. Display 'roleLabel'	
1.4.1	Generate pick-list from Reportable Event body/relevant finding/laboratory finding/topic/ preferredLabel and display Lab finding (all associated clinical findings)	
1.4	The picklist should be generated from the information stored in the MDR. (ie select distinct Reportable Event header/ contextOfUse/spatial/ 'preferredLabel')	

1.4	If the user role is “Laboratory” then generate pick-list from Reportable Event body/relevant finding/laboratory finding/topic/ preferredLabel and display Lab finding (all associated clinical findings concatenated)
1.4	If the user role is “Hospital” or “Healthcare Provider” then generate pick-list from Reportable Event body/relevant finding/laboratory finding/topic/ preferredLabel and display Clinical finding (all associated lab findings concatenated)
1.4	On the backend, the ‘name of the reportable event’ is not always the same as the clinical topic or the laboratory topic. Each Reportable Event Asset stored in the MDR will contain three fields that will be used for query and display: - Clinical topic - Laboratory topic - Name of reportable event (stored in Reportable Event header/resource displayLabel)
1.5.1	Use the function- is_active_resource(asset_resource_id) to manage the “Currently active events” query input.
2.5	Use “Resource_Activate_date” from the Asset Resource table to manage the “events updated since..” query input.



APPENDIX E

SCRIPT USED DURING THE USABILITY TESTING WITH THE WEB-BASED PUBLIC HEALTH REPORTING SYSTEM

Script for Users Representing Reporting Compliance Officers from Laboratories or Infection Preventionists from Hospitals

Public health reporting is mandatory for laboratories and clinical facilities. Currently, reporting specifications are published by public health departments on individual department websites. We are developing a web-based prototype public health reporting system that would include public health reporting specifications for laboratories, healthcare providers, and hospitals. The purpose of this session is to assure that we are developing a user-friendly application that meets the needs of the users. We have identified three scenarios that we would like to test in this usability session. The three scenarios and the specific tasks associated with each scenario are below:

Scenario 1

You are working at a laboratory/hospital. You have been tasked with identifying the reporting specifications for all conditions reportable in multiple jurisdictions.

Tasks:

i. Identify the laboratory reporting specifications for conditions reportable in the following jurisdictions: Colorado, Utah, and Washington.

ii. Identify the hospital reporting specifications for conditions reportable in the following jurisdictions: Colorado, Utah, and Washington.

Questions:

a) What did you think of the content organization and display on the query screen while conducting the tasks for this scenario?

b) Does the information flow make sense to a laboratory/hospital user?

c) The display for laboratories shows the reporting time frame and the requirement for specimen submission. Would you want any other data elements to be displayed in this view?

d) The display for laboratories displays the information based on the laboratory finding with the reportable condition in the parenthesis. Do you agree with this display?

e) The display for hospitals shows only the reporting time frame. Would you like any other data elements to be displayed in this view?

f) The display for hospitals displays the information based on the reportable condition and does not specify either the clinical finding or the laboratory finding. Do you agree with this display?

Scenario 2

You are working at a laboratory/hospital. You have been tasked with identifying the reporting specifications for all conditions reportable in a particular jurisdiction.

Tasks:

i. Identify the laboratory reporting specifications for conditions reportable in either one of the jurisdictions: Colorado, Utah, and Washington.

ii. Identify the hospital reporting specifications for conditions reportable in either one of the jurisdictions: Colorado, Utah, and Washington.

Questions:

a) What did you think of the organization and display of the query screen while conducting the tasks for this scenario?

b) Does the information flow make sense to a laboratory/hospital user?

c) The display for laboratories shows the reporting time frame, the requirement for specimen submission, and the preferred method of reporting. Would you want any other data elements to be displayed in this view?

d) The display for hospitals shows the reporting time frame, the link to the form, and the preferred method of reporting. Would you like any other data elements to be displayed in this view?

e) You can obtain the reportable specifications for a specific jurisdiction from the view that displays all the conditions reportable in multiple jurisdictions by clicking on the specific jurisdiction. For example: Utah. Is this conveyed by the current display?

Scenario 3

You are working at a laboratory/hospital. You want to identify the reporting specifications for Chlamydia trachomatis for either of the jurisdictions: Colorado, Utah, and Washington.

Tasks:

i. Identify the laboratory reporting specifications for Chlamydia trachomatis in either one of the jurisdictions: Colorado, Utah, and Washington.

ii. Identify the hospital reporting specifications for Chlamydia trachomatis in either one of the jurisdictions: Colorado, Utah, and Washington.

Questions:

a) What did you think of the content organization and display on the query screen while conducting the tasks for this scenario?

b) Does the information flow make sense to a laboratory/hospital user?

c) The default display for laboratories shows the reporting action. The specimen submission requirement, reporting criteria, and references are displayed using progressive disclosure. Do you agree with this display?

d) The default display for hospitals shows the reporting action. The reporting criteria and references are displayed using progressive disclosure. Do you agree with this display?

e) You can obtain the reportable specifications for Chlamydia trachomatis for a specific jurisdiction from the view that displays all the conditions reportable in multiple jurisdictions by clicking on the associated reporting time frame. For example: 3 days. Is this conveyed by the current display?

f) You can also obtain the reportable specifications for Chlamydia trachomatis for a specific jurisdiction from the views that displays all the conditions reportable in that jurisdiction by clicking on the reportable condition. For example: Chlamydia trachomatis. Is this conveyed by the current display?

Script for Users Representing Public Health Epidemiologists

Public health reporting is mandatory for laboratories and clinical facilities. Currently, reporting specifications are published by public health departments on individual department websites. We are developing a web-based prototype public health reporting system that would include public health reporting specifications for laboratories, healthcare providers, and hospitals. The purpose of this session is to assure that we are developing a user-friendly application that meets the needs of the users. We have identified three scenarios that we would like to test in this usability session. The three scenarios and the specific tasks associated with each scenario are below:

Scenario 1

You are a public health epidemiologist. You want to find out if the reporting specifications displayed in the 'Multiple states all conditions' are accurate.

Tasks:

i. Identify the laboratory reporting specifications for conditions reportable in the following jurisdictions: Colorado, Utah, and Washington.

ii. Identify the hospital reporting specifications for conditions reportable in the following jurisdictions: Colorado, Utah, and Washington.

iii. Identify the healthcare reporting specifications for conditions reportable in the following jurisdictions: Colorado, Utah, and Washington.

Questions:

(a) What did you think of the content organization and display on the query screen while conducting the tasks for this scenario?

(b) Does the information flow make sense to a laboratory/hospital/clinical user?

(c) The display for laboratories shows the reporting time frame and the requirement for specimen submission. Would you want any other data elements to be displayed in this view?

(d) The display for laboratories displays the information based on the laboratory finding with the reportable condition in the parenthesis. Do you agree with this display?

(e) The display for hospitals/healthcare provider shows only the reporting time frame. Would you like any other data elements to be displayed in this view?

(f) The display for hospitals/healthcare provider displays the information based on the reportable condition and does not specify either the clinical finding or the laboratory finding. Do you agree with this display?

Scenario 2

You are a public health epidemiologist. You want to find out if the reporting specifications displayed in the 'One state all conditions' are accurate.

Tasks:

i. Identify the laboratory reporting specifications for conditions reportable in either one of the jurisdictions: Colorado, Utah, and Washington.

ii. Identify the hospital reporting specifications for conditions reportable in either one of the jurisdictions: Colorado, Utah, and Washington.

iii. Identify the healthcare reporting specifications for conditions reportable in either one of the jurisdictions: Colorado, Utah, and Washington.

Questions:

(a) What did you think of the content organization and display on the query screen

while conducting the tasks for this scenario?

(b) Does the information flow make sense to a laboratory/hospital/clinical user?

(c) The display for laboratories shows the reporting time frame, the requirement for specimen submission, and the preferred method of reporting. Would you want any other data elements to be displayed in this view?

(d) The display for laboratories shows the reporting time frame, the link to the form, and the preferred method of reporting. Would you like any other data elements to be displayed in this view?

(e) You can obtain the reporting specifications from the view that displays all the conditions reportable in multiple jurisdictions by clicking on the specific jurisdiction. For example: Utah. Is this conveyed by the current display?

Scenario 3

You are a public health epidemiologist. You want to find out if the reporting specifications displayed in the 'One state one condition' are accurate.

Tasks:

i. Identify the laboratory reporting specifications for Chlamydia trachomatis in either one of the jurisdictions: Colorado, Utah, and Washington.

ii. Identify the hospital reporting specifications for Chlamydia trachomatis in either one of the jurisdictions: Colorado, Utah, and Washington.

iii. Identify the healthcare reporting specifications for Chlamydia trachomatis in either one of the jurisdictions: Colorado, Utah, and Washington.

Questions:

(a) What did you think of the content organization and display on the query screen

while conducting the tasks for this scenario?

(b) Does the information flow make sense to a laboratory/hospital/clinical user?

(c) The default display for laboratories shows the reporting action. The specimen submission requirement, reporting criteria, and references are displayed using progressive disclosure. Do you agree with this display?

(d) The default display for hospitals/healthcare providers shows the reporting ac tion. The reporting criteria and references are displayed using progressive dis closure. Do you agree with this display?

(e) You can obtain the reporting specifications for Chlamydia trachomatis for a specific jurisdiction from the view that displays all the conditions reportable in multiple jurisdictions by clicking on the associated reporting time frame. For example: 3 days. Is this conveyed by the current display?

(f) You can also obtain the reporting specifications for Chlamydia trachomatis for a specific jurisdiction from the view that displays all the conditions reportable in that jurisdiction by clicking on the reportable condition. For example: Chlamydia trachomatis. Is this conveyed by the current display?

APPENDIX F

REQUIRED DATA ELEMENTS FOR ELECTRONIC CASE REPORTING

AND THEIR RESPECTIVE HL7 V2.5 SEGMENT POSITIONS

Concept	***HL7 V2.5 Message position of concept***	***HL7 V2.5 Message position of value***	***Description***
Reporting Information			
Date/time Alert created	OBX.3.CE "LOINC"	*OBX.5.TS*	Date/ time automated detection system identified reportable condition.
Date of report to public health authority		*MSH.7.TS*	The date that the Case Report is being sent to the health department.
Reporting System		*MSH.3.HD*	System used to report cases to the health department
Reporting Facility Name		*MSH.4.HD*	The name of the facility sending the Case Report to the health department.
Reporting contact's name	OBX.3.CE "LOINC"	OBX.5.XPN	The name of the person to be contacted about case reports sent to the health department.
Reporting contact's phone	OBX.3.CE "LOINC"	*OBX.5.XTN*	The phone number of the person to be contacted about case reports sent to the health department
Facility phone number	OBX.3.CE "LOINC"	*OBX.5.XTN*	The phone number of the facility that diagnosed the subject of the Case Report.
Facility address	OBX.3.CE "LOINC"	*OBX.5.XAD*	The address (Street, City, State, Zip Code) of the facility that diagnosed the subject of the Case Report.
Reporting Contact's email	OBX.3.CE "LOINC"	*OBX.5.XTN*	The email of the person to be contacted about case reports sent to the health department

Concept	***HL7 V2.5 Message position of concept***	***HL7 V2.5 Message position of value***	***Description***
Reporting Contact's Address	OBX.3.CE "LOINC"	*OBX.5.XAD*	The address (Street, City, State, Zip Code) of the person to be contacted about case reports sent to the health department
Health Care Provider Information			
Provider name	OBX.3.CE "LOINC" **52526-1**	*OBX.5.XPN*	The name of the person that diagnosed the subject of the Case Report
Provider phone	OBX.3.CE "LOINC"	*OBX.5.XTN*	The phone number of the person that diagnosed the subject of the Case Report
Provider address	OBX.3.CE "LOINC"	*OBX.5.XAD*	The address of the person that diagnosed the subject of the Case Report
Provider ID	OBX.3.CE "LOINC" **22025-1**	*OBX.5.NM*	Unique identifier for provider
Provider facility	OBX.3.CE "LOINC"	*OBX.5.XON*	The name of the facility in which the health care provider diagnosed the subject of the Case Report.
Subject Information			
Patient Name		*PID.5.XPN*	The name (preferably legal) of the subject of the case report.
Patient Address		*PID.11.XAD*	The address of the subject of the case report
Patient County of residence		*PID.12.IS*	The county of the address of the subject of the case report.
Patient Telephone		*PID.13.XTN*	The telephone number of the subject of the case report.
Patient Age	OBX.3.CE "LOINC": 21612-7	*OBX.5.NM*	The age of the subject of the case report at time of diagnosis
Patient Date of Birth		*PID.7.TS*	The date of birth (MM/DD/YYYY) of the subject of the case report.
Patient Gender		*PID.8.IS*	The current gender of the subject of the case report.
Ethnicity		*PID.22.CE*	The Ethnicity of the subject of the case report.
Race		*PID.10.CE*	The Race(s) of the subject of the case report.

Concept	***HL7 V2.5 Message position of concept***	***HL7 V2.5 Message position of value***	***Description***
Occupation	OBX.3.CE "LOINC": 11340-7	*OBX.5.ST*	The Occupation of subject of the case report. Enter as much detail as possible (e.g. Teacher in Pre-School facility)
Pregnancy status of Patient	OBX.3.CE "LOINC": 11449-6	*OBX.5.ST*	Enter Yes/No with regards to if the subject of the case report was pregnant at time of diagnosis.
Clinical Information			
Name of reportable Condition		*OBR.31.CE.*	The name of the Condition diagnosed for the subject of the Case Report.
Date of onset	OBX.3.CE "LOINC" 11368-8	*OBX.5.TS*	The date that the subject began having symptoms of condition being reported.
Date of Diagnosis	OBX.3.CE "LOINC"	*OBX.5.TS*	The date that the subject of the Case Report was diagnosed with the reportable condition
Hospitalization status		*PV1.2.IS*	Patient class at the time the alert is created
Admit date		*PV1.44.TS*	Enter the date that the subject of the Case Report was admitted to the hospital.
Admit Diagnosis	OBX.3.CE "LOINC: 42347-5"	*OBX.5.ST*	Diagnosis at the time of admission
Room Number	OBX.3.CE "LOINC: 45403-3"	*OBX.5.ST*	Room number if patient is hospitalized
Unique Patient ID		*PID.3.CX*	Unique number identifier for the entire healthcare enterprise
Medical record number		*PID.4.CX*	Unique number identifier for the hospital or clinic
Encounter Number		*PVI.19.CX*	Unique Number identifier for the encounter
Facility associated with encounter number	OBX.3.CE "LOINC"	*OBX.5.XON*	Name of the healthcare facility associated with encounter - NOTE: this may be an outpatient clinic or some other facility that may need to be separately identified from the facility that is doing the reporting.

Concept	***HL7 V2.5 Message position of concept***	***HL7 V2.5 Message position of value***	***Description***
Hospital Service		*PV1.10.IS*	Hospital service with primary responsibility for the patient
Previous Admission date	OBX.3.CE "LOINC"	*OBX.5.TS*	Admit date of previous encounter
Previous discharge date	OBX.3.CE "LOINC"	*OBX.5.TS*	Discharge date of previous encounter
Diagnostic Information			
Ordering clinician name		*OBR.16.XCN*	Name of the person who ordered the lab test - this is in the lab record
Ordering clinician phone		*OBR.17.XTN*	Phone number of the person who ordered the lab test
Ordering clinician facility	OBX.3.CE "LOINC"	*OBX.5.XON*	Name of the facility of the person who ordered the lab test
Ordering clinician ID number	OBX.3.CE "LOINC": 18780-7	*OBX.5.XCN*	Unique identifier for person who ordered the test
Specimen collection date		*OBR.7.TS*	The date that the specimen for the laboratory test was taken from the subject of the Case Report.
Test Status		*OBR.25.ID*	Status of test result reported (preliminary, final, corrected)
Source of specimen		*OBR.15.SPS*	The physical body location from where the specimen for the lab report was taken from the subject.
Test name/ detection method		OBX.3.CE	Observation method / Name of the test
Test result and comments		*OBX.5.CE*	The test result of the laboratory test including any applicable result units of measure.
Lab order Accession number		*OBR.2.EI*	Unique ID for the lab order - needed to link updated and corrected results over time and link with ELR reports
Reference range		*OBX.7.ST*	The reference range of the lab test result
Abnormal flags		*OBX.8.IS*	Indicators to denote abnormal lab test results
Date of test		*OBX.19.TS.*	The date that the laboratory test was performed for the subject of the Case Report.

Concept	***HL7 V2.5 Message position of concept***	***HL7 V2.5 Message position of value***	***Description***
Specimen Received in lab date/time		*OBR.14.TS*	Requested particularly for those situations when specimens are collected in the field
Laboratory Name		*OBX.15.CE*	Name of the laboratory that did the testing
Date/time results reported to the ordering provider	OBX.3.CE "LOINC"	*OBX.5.TS*	Date/time laboratory reported results to the ordering provider
Medications			
Current Antibiotics	OBX.3.CE "LOINC: 18605-6"	*OBX.5.ST*	Antibiotics given to the subject at present.

APPENDIX G

SNOMED CT (INTERNATIONAL VERSION 0807) CODES IDENTIFIED

FOR REPORTABLE CONDITIONS IN UTAH

S.No	Utah's reportable conditions	Snomed code	Snomed CT term
Reportable Immediately			
1	Anthrax	409498004	Anthrax
2	Botulism	No appropriate code available	
3	Cholera	63650001	Cholera
4	Diphtheria	397430003	Diphtheriae due to Corynebacterium diphtheriae
5	Haemophilus influenzae (invasive disease)	406583002	Invasive hemophilus influenzae disease
6	Hepatitis A	25102003	Acute type A viral hepatitis
7	Measles (Rubeola)	14189004	Measles
8	Meningococcal disease	23511006	Meningococcal infectious disease
9	Plague	58750007	Plague
10	Poliomyelitis (paralytic)	240460008	Acute paralytic poliomyelitis
11	Rabies (human and animal)	14168008	rabies
12	Rubella	36653000	rubella
13	Severe Acute Respiratory Syndrome (SARS)	398447004	severe acute respiratory syndrome
14	Smallpox	67924001	smallpox
15	Staphyloccus aureus with resistance (VRSA) or intermediate resistance (VISA) to vancomycin isolated from any site	406577000	infection due to vancomycin intermediate/resistant staphylococcus aureus

S.No	Utah's reportable conditions	Snomed code	Snomed CT term
16	Syphilis	76272004	syphilis
17	Tuberculosis	No appropriate code available	
18	Tularemia	19265001	tularemia
19	Typhoid (cases and carriers)	No appropriate code available	
20	Viral hemorrhagic fever	240523007	viral hemorrhagic fever
21	Yellow fever	16541001	yellow fever
Reportable within three working days			
22	Acquired Immunodeficiency Syndrome (AIDS)	62479008	AIDS
23	Adverse event resulting after smallpox vaccination	409636005	complication of smallpox vaccination
24	Amebiasis	388759003	infection due to entamoeba histolytica
25	Arbovirus infection, including Saint Louis encephalitis and West Nile virus infection	417093003	disease due to West Nile virus
		417192005	St.Louis encephalitis virus infection
		416707008	Powassan encephalitis virus infection
		416925005	Eastern equine encephalitis virus infection
		47523006	Western equine encephalitis
		416442006	California encephalitis virus infection
26	Brucellosis	No appropriate code available	
27	Campylobacteriosis	No appropriate code available	
28	Chancroid	266143009	Chancroid
29	Chickenpox	38907003	varicella
30	Chlamydia	240589008	Chlamydia trachomatis infection
31	Coccidioidomycosis	60826002	Coccidioidomycosis

S.No	Utah's reportable conditions	Snomed code	Snomed CT term
32	Colorado tick fever	6452009	Colorado tick fever
33	Creutzfeldt- Jakob disease and other transmissible human spongiform encephalopathies	No appropriate code available	
34	Cryptosporidiosis	240370009	Cryptosporidiosis
35	Cyclospora infection	240372001	Cyclosporiasis
36	Dengue fever	38362002	Dengue
37	Echinococcosis	74942003	Echinococcosis
38	Ehrlichiosis (human granylocytic, human monocytic, or unspecified)	240626005	Human Ehrlichiosis
39	Encephalitis	45170000	Encephalitis
40	Shiga toxin-producing Escherichia coli (STEC) infection	116395006	EHEC, Escherichia coli
41	Giardiasis	58265007	Giardiasis
42	Gonorrhea (sexually transmitted and ophthalmia neonatorm)	15628003	Gonorrhea
43	Hansen disease (leprosy)	81004002	leprosy
44	Hantavirus infection and pulmonary syndrome	120639003	Hantavirus pulmonary syndrome
45	Hemolytic Uremic Syndrome (postdiarrheal)	373421000	Diarrhea-associated Hemolytic Uremic Syndrome
46	Hepatitis B (cases and carriers)	66071002	Type B viral hepatitis
		76795007	Acute type B viral hepatitis
		61977001	Chronic type B viral hepatitis
47	Hepatitis C (acute and chronic infection)	50711007	viral hepatitis C
		235866006	Acute hepatitis C
		128302006	Chronic hepatitis C
48	Hepatitis (other viral)	235865005	Hepatitis D superinfection of hepatitis B carrier
		235867002	acute hepatitis E virus
		No code available	

S.No	Utah's reportable conditions	Snomed code	Snomed CT term
		for Hepatitis G	
		No code available for Hepatitis F	
49	Human Immunodeficiency virus (HIV) infection	86406008	Human Immunodeficiency virus infection
50	Influenza-associated hospitalization	No appropriate code available	
51	Influenza-associated death in a person less than 18 years of age	No appropriate code available	
52	Legionellosis	26726000	Legionnella infection
53	Listeriosis	4241002	Listeriosis
54	Lyme disease	No appropriate code available	
55	Malaria	61462000	Malaria
56	Meningitis	7180009	Meningitis
57	Mumps	36989005	Mumps
58	Norovirus (formerly called Norwalk-like virus) infection	24789006	viral gastroenteritis due to Norwalk-like agents
59	Pelvic inflammatory disease	198130006	inflammatory disease of female pelvic organs AND/OR tissues
60	Pertussis	27836007	pertussis
61	Poliovirus infection (non-paralytic)	429297003	Acute nonparalytic poliomyelitis due to human poliovirus 1
62	Psittacosis	No appropriate code available	
63	Q fever	186788009	Q fever
64	Relapsing fever(tick-borne or louse borne)	10301003	tick-borne relapsing fever
		14683004	louse borne relapsing fever
65	Rocky mountain spotted fever	186772009	Rocky mountain spotted fever
66	Rubella (congenital syndrome)	1857005	gestational rubella syndrome

S.No	Utah's reportable conditions	Snomed code	Snomed CT term
67	Salmonellosis	No appropriate code available	
68	Shigellosis	36188001	Shigellosis
69	Streptococcal disease (invasive, organism isolated from a norrmally sterile site)	406610002	invasive streptococcal disease
70	Tetanus	76902006	tetanus
71	Toxic-Shock Syndrome staphylococcal	240450004	staphylococcal toxic shock syndrome
72	Streptococcal Toxic shock syndrome	240451000	streptococcal toxic shock syndrome
73	Trichinosis	88264003	infection by larvae of Trichinella spiralis
74	Vibriosis	398557001	infection due to non-cholerae vibrio